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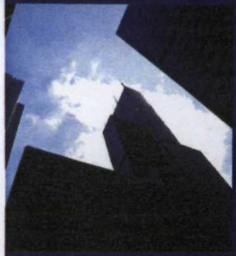
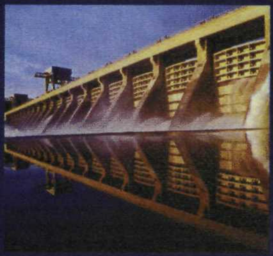


Nature and Extent Evaluation

Mallard Lake Landfill
Hanover Park, Illinois

Volume I of II

STS Project No. 200704805

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Mallard Lake Landfill
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April 7, 2008

Mr. Steven J. Faryan
On-Scene Coordinator
EPA Region 5
77 W. Jackson Blvd.
Chicago, IL 60604-3590

RE: Nature and Extent Report
EPA Docket No. RCRA 7003-5-08-001
Mallard Lake Landfill, Hanover Park, IL
STS Project No. 200704805

Dear Mr. Faryan:

Attached please find an original and 12 copies of the Mallard Lake Landfill Gas Migration Nature and Extent report. Two copies of the report have also been sent to Weston Solutions at their Vernon Hills Offices. This report is submitted pursuant to the requirements of paragraph 59 Administrative Order on Consent (AOC). It provides the findings of the investigations conducted over the past several months. The report is anticipated to provide a basis for the off-site corrective measures plan which will be submitted during the next 60 days.

Please do not hesitate to contact Craig Rawlinson at 847-279-2449 with any questions or comments on the attached report.

Sincerely,

Steven C. Kornder, Ph.D.
Senior Geochemist

Craig S. Rawlinson, P.G.
Associate Hydrogeologist

cc: Ms. Mary Setnicar, EPA Region 5
Mr. Eric Ballenger, BFI
Mr. Jim Hitzeroth, BFI
Mr. Joseph Benedict, Forest Preserve District of DuPage County

Document Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature JLWhite

Name Jo Lynn White

Title Corporate Secretary

Date 4-7-08

Table of Contents

Tables

Figures

Drawings

Appendices

1.0 Background Information

1.1 Site Location

The facility boundary of the Mallard Lake Landfill encompasses approximately 534 acres (refer to Figure 1) of which the total area utilized for solid waste disposal was approximately 230 acres. The landfill is situated on the property owned by the Forest Preserve District of DuPage County (FPDDC) and within the Mallard Lake Forest Preserve as shown in Figure 1. In general, the facility is located in portions of sections 12 and 13, township 40 north, range 9 east, and portions of sections 7, 17, and 18 townships, 40 North, range 10 East. The landfill is bounded on the south side by Schick Road; to the west by the US Homes subdivision and by private residences along County Farm Road; to the north by the West Branch of the DuPage River and the Mallard North Landfill, and to the east by the Mallard Lake Forest Preserve

1.2 Permit History

Mallard Lake Landfill is owned by the Forest Preserve District of DuPage County. The landfill facility is currently undergoing post-closure care and is operated by BFI Waste Systems of North America, LLC (BFI). The Mallard Lake Landfill became operational in March 1975 in accordance with the requirements of Illinois Environmental Protection Agency (IEPA) operating permit number 1974 –17 – OP. This permit provided for development and operation of two hills for solid waste disposal. The two hills were identified as the North Hill and the South Hill. These two areas of solid waste disposal consisted of approximately 117 acres. In 1982, an expansion of the landfill was proposed to join the two hills into one contiguous unit for solid waste disposal. This modification was done in accordance with the requirements of the Illinois Environmental Protection Act, section 39.2. This expansion resulted in total area for solid waste disposal of approximately 230 acres. Siting approval for the expansion was granted by way of County Board Resolution on April 27, 1982. On June 4, 1982, the IEPA granted approval to develop and expand the facility in accordance with permit number 1982 –17 – DE\OP. Subsequent to these developments and operating permits, IEPA issued various supplemental permits which modified the operating and monitoring plans for the facility. The Mallard Lake Landfill accepted municipal solid waste, demolition wastes, construction waste and permitted non-hazardous special waste. In December 1998, the facility was issued its first significant permit modification (Permit No. 1997-2223-LFM) which authorized the facility to continue operating in compliance with Illinois subtitle G. regulations and Federal Subtitle D regulations. Mallard Lake Landfill ceased accepting waste on March 13, 1999. The facility was certified closed on December 30, 2001. A total of 31 significant permit modifications have been issued under permit number 1997 – 223 – LFM. These modifications address a wide variety of operating, monitoring, closure, post closure, corrective action and financial assurance related changes to the permit.

1.3 Existing Conditions/Landfill Design

As previously noted, the Mallard Lake Landfill is comprised of two hills, the South Hill and the North Hill, as well as an expansion area which joins these two original hill areas. As shown by Drawing 1, waste filling occurred to elevations not believed to extend deeper than 740 mean sea level (MSL). The landfill was closed in a phased manner pursuant to the regulations which existed at the time final cover was placed on each of the cells. Drawing 2 depicts the various cell areas of the landfill. The perimeter slope areas of the landfill were closed first in order to stabilize the slope areas from erosion. The southern portion of the South Hill as well as the A1, A2 and A3 disposal areas received final cover consisting of re-compacted clay uncompacted vegetative zone soils and topsoil with vegetative growth. Similarly, the clay lined areas in the north hill, referred to as the B-8 and the B-9 areas, were also closed with a re-compacted clay cover. In December 1999, a significant permit modification was approved to allow the landfill to be closed utilizing geo-composite clay cover. The geocomposite closure area comprised the bulk of the landfill surface area approximately 135 acres. The geocomposite clay cover consisted of a minimum of 12 inches of re-compacted clay liner overlain by a Bentomat™ geocomposite clay liner (GCL). The Bentomat™ GCL consisted of a 40 mil thick linear low density polyethylene liner (LLDPE) with attached non-woven geotextile containing bentonite. The entire landfill had received final cover by December 2001 and was deemed to have been closed in compliance with the site's closure plan on December 30, 2001.

As in the case of the landfill cover, the landfill liner systems also reflect variations in design and construction reflecting regulatory changes which were implemented during the course of the landfill operations. The liner types ranged from documented in situ clay soils, to a re-compacted clay liner and finally to a geocomposite clay liner within the lateral expansion area located between the two hills. As previously stated this lateral expansion area was the last area to be filled. Figure 2 depicts the various liner designs used during the construction of the landfill. The landfill or base elevations are depicted in Drawing 1. As shown by Drawing 1, the landfill base grades were designed to drain to a series of sumps located along the perimeter of the landfill. These sumps are utilized to pump leachate to a conveyance piping system that extends along the perimeter of the landfill. Leachate is also collected from combination gas and leachate extraction wells located throughout the South Hill Area. The leachate is then pumped to the north via a force-main to the publicly owned treatment works in the Village of Hanover Park. The landfill gas management system consists of gas collection wells and lateral piping which are connected to the gas to energy plant via a header piping system. The gas to energy plant utilizes a system consisting of three turbines to generate energy which is sold to the local power grid. The gas-to-energy plant is operated by Gas Recovery Systems Inc. (GRS) and is located near the southwest corner of the landfill.

The landfill's groundwater monitoring network consists of 38 groundwater monitoring wells; 22 of these wells are completed within the uppermost aquifer system which is defined as the combination of the basal Lemont Formation and the underlying Silurian Dolomite bedrock. The basal permeable zones of the Lemont Formation are hydraulically connected to the bedrock and thus behave as a single aquifer system. The remaining 16 monitoring wells are completed within the permeable zones within the Wadsworth Formation which overlies the Lemont. The landfill gas monitoring network consists of 60 gas probes located around the perimeter of the landfill (refer to Drawing 3 for the Environmental Monitoring Plan).

1.4 Previous Site Investigations

The Mallard Lake Landfill is more than 30 years old and has undergone several phases of investigation. A brief summary of the many investigators who have prepared reports which have been utilized to develop this migration investigation are described below:

There were several letter reports and recommendations made by Charles Moore of Geotechnics, Inc. during the period 1985–1987. In an October 1985 letter to the FPDDC, recommendations were made for additional gas monitoring probes along the west side of Mallard Lake Landfill. In a preliminary report on hydrogeology transmitted by letter to the FPDDC in January 1986, three distinct groundwater regimes were identified with further recommendations for maintaining hydrogeological control of gas migration by maintaining saturated conditions. Studies have shown that saturated soils present a significant barrier to combustible gas migration.

Moore's evaluation included an assessment of the influence of the piezometric groundwater elevations and the presence of surface water bodies on landfill gas migration. Moore also addressed the effects of construction activities on the migration and attenuation of landfill gas. Moore suggested that isolated sand units exhibiting partially saturated to unsaturated conditions may in fact have resulted from the operational diversion of natural surface water patterns to accommodate the on-site landfill waste disposal activities. It was suggested that surface water diversion disrupted the natural system of maintaining saturated conditions in the subsurface. It was suggested that remedial actions include channeling surface water or injecting water to deeper unsaturated isolated deposits in order to reestablish the natural saturated conditions.

In 1988, Dr. J. Bogner was contracted by the FPDDC through Geotechnics, Inc. to develop a report on the geology of the Mallard Lake and Mallard North Landfills, including discussion of units that might have a potential for gas or leachate migration (Bogner, 1988). This report used existing site borings supplemented by borings from the files of the Illinois State Geological Survey (ISGS) and included both localized cross-sections and a regional cross-section which merged site geologic interpretations with the regional Pleistocene stratigraphy developed by the ISGS. In general, the sequence of geologic units at the site (not including the landfilled waste) included the following:

Fill: Silty clay fill and replaced topsoil
Alluvium: Cahokia alluvium deposited by modern rivers
Wadsworth Formation, including:
W1: Silty clay diamicton, trace sand and gravel, water content (gravimetric) 20-25%;

W1/W2 Interface:	Discontinuous silty sand, sandy silt, clayey sand and gravel, clayey silt, including fluvial, lacustrine, diamicton material, highly variable, maximum thickness 15 ft.;
W2:	Silty clay diamicton, little sand and gravel, water content 15-20%, may contain pockets and discontinuous lenses of fluvial or lacustrine material;
W3:	Clayey silt to sandy silt diamicton, little to some sand and gravel, water content 10-15%, may contain pockets and discontinuous lenses of fluvial or lacustrine material that are locally thick;
W4:	Silty clay diamicton, little to some sand and gravel, water content 15-20%, may contain pockets and discontinuous lenses of fluvial or lacustrine material;

Wadsworth/Lemont Interface: May be thin cobble zone or sand, gravel, silt, or silty clay present. Generally sharp contrast in blow counts between Wadsworth Formation (<30) and Lemont Formation (>40) with decrease in water content compared to W4.

Lemont Formation, including the following facies (not all present due to high variability in localized depositional environments):

L1: Fluvial sand and gravel, silty sand, lacustrine silt/clayey silt. Lemont outwash or proglacial Wadsworth.
L2: Sandy silt diamicton, some gravel, water content <15%; generally >20% sand and gravel
L3: Sand and gravel, coarsening upward, proglacial Lemont (fluvial)
L4: Silt, silty clay, fine sand, generally massive, proglacial Lemont (lacustrine)
L5: Bedrock rubble zone (angular dolomite fragments) with sand and gravel

Silurian Dolomite bedrock (BR, undifferentiated).

This report had the following conclusions regarding potential gas migration issues associated with units which could be locally coarse-grained:

1. The W1/W2 is relatively thin, is discontinuous, but tends to be laterally present across the site. Where present, this unit is typically moist to saturated, particularly where it contains a high percentage of coarse-grained material. It may be a potential unit for gas migration where it occurs at higher elevations and is seasonally unsaturated.

2. Thin, discontinuous sand and gravel interbeds within the W1-W4 diamictons are typically discontinuous and often saturated. If "moist" to "dry", they could have localized potential for gas migration.

3. Mostly composed of sandy silt diamictons, silty lacustrine sequences, and thin sands and gravels under the Mallard Lake site, the Lemont Formation can regionally include basal sands and gravels which are hydrogeologically connected with the upper bedrock aquifer (Silurian Dolomite). Where penetrated by existing borings, the L sediments are typically described as "wet" or "saturated" under the Mallard Lake site. These sediments could have issues related to gas migration if "dry" or "moist." However, no site conditions have been identified which result in the Lemont Formation being dewatered.

Bogner (1989) reviewed Mallard Lake hydrogeology and commented extensively on previous investigations, memos, and reports. In particular, the current disequilibrium status of the shallow groundwater regime was discussed.

Bogner and Moore (1993) developed a summary report on the hydrogeology of the Mallard Lake Landfill, especially with regard to gas migration along a north-south cross-section along the western boundary of the site. This report concluded that:

1. Hydrogeologically there appears to be a consistent perched reservoir of ground water at higher elevations, a relatively saturated zone of downward percolation at intermediate elevations, and an artesian condition in and above the dolomite bedrock (piezometric surface at that time of about 740 ft MSL).

2. The W1/W2 appears to be hydraulically connected to surrounding streams and lakes, with a hydrostatic head between 765 and 775 ft MSL. The W1/W2 is more extensive in the north central portion of the Mallard Lake site and may be unsaturated where it occurs above 765 ft MSL.

3. Although the W1/W2 is topographically high and seasonally unsaturated at stations 45+50 through 58+00, at the time of this report most of this material was scheduled to be excavated during the course of future landfilling operations. However, continued scrutiny was recommended with respect to mapping and monitoring of the W1/W2 unit.

Geotechnics (1993), based on a series of nested probes installed at the Mallard Lake Landfill site and a series of pumping tests, concluded that the grain size and degree of saturation of permeable backfill materials influenced the response time of individual probes to purging and sampling. A relationship between the median grain size and median pumping time was developed. This study was conducted to determine if groundwater monitoring probes of the standard design used at Mallard were also suitable for monitoring landfill gas.

Terracon (1994) was contracted to install a series of passive gas vent wells along the south side of the landfill in the vicinity of probes P6B and GP-2. Approximately 10 vent wells (GVM-3 through GVM-12) were installed (refer to Figures 3 and 4 for locations) and equipped with wind turbines in order to promote venting. The system was only marginally effective since groundwater in the W1/W2 unit flooded the gas venting wells.

Ries Environmental Inc. (1997) was contracted to compile the engineering portions of the first significant permit modification application. The application included engineering design plans, operation plans, as well as closure and post closure care plans.

RUST Environmental and Infrastructure Inc. (1997) was contracted to prepare the Hydrogeologic Investigation Reports and Groundwater Impact Assessment for the initial significant permit modification application. Supplemental drilling, well installation and soil testing was conducted to support the engineering and groundwater impact assessment analyses. The permit application was submitted to IEPA in June 1997. IEPA comments on the application were received in September 1997. STS was contracted in October 1997 to prepare addendums responding to the IEPA comments. These addendums were submitted in December 1997, August 1998 and November 1998. Permit was received in December 1998.

Woodward Clyde was contracted in 1997 to upgrade the landfill gas management system to provide gas management capacity within the south, north hill and lateral expansion areas. The work proceeded for three years and completed once the landfill ceased accepting waste.

In April 1998, STS conducted an assessment monitoring investigation into groundwater quality exceedances at monitoring well R112. A cone penetrometer testing (CPT) investigation was conducted to evaluate whether the monitoring well had been influenced by either leachate migration or landfill gas contact. The cone penetrometer encountered pressurized gas at a depth of approximately 55 ft below ground surface (bgs). Groundwater pressures as high as 4.5 psi were observed during the CPT study. The evaluation determined that the groundwater in the vicinity of well R112 had been influenced by contact with landfill gas. IEPA agreed that a zone of attenuation (ZOA) monitoring well should be installed at a point 100 ft from the landfill (ZOA boundary) in the vicinity of well R112. Monitoring well G52S was installed in August 1998. Subsequent groundwater quality monitoring indicated the presence of low levels of vinyl chloride at monitoring wells G52S and G131.

In late 1999, an assessment of the corrective measures was conducted to evaluate potential remedial action to address the vinyl chloride concentrations detected at wells G52S and G131 (refer to Drawing 3 for location of wells). At approximately the same time, the landfill was implementing the final closure which consisted of final cover placement and installation of additional landfill gas extraction wells. The corrective measures assessment suggested that additional time be provided to allow the recently expanded or upgraded landfill gas collection system to influence the gas concentrations and pressures in the vicinity of the affected monitoring wells. The corrective measures assessment was presented in a public meeting in early April 2000 and was subsequently submitted to IEPA as an application for significant permit modification. A permit application was approved and included a condition that annual evaluations be conducted to determine whether the corrective action measures were effective. This permit application was approved in the fall of 2000. The first evaluation of the corrective action system effectiveness was submitted by Herst and Associates in July 2001. The evaluation suggested that the vinyl chloride concentrations were not responding to the internal landfill gas extraction efforts. As such, it was determined that an external corrective action system would be required.

STS was contracted to conduct a pilot study to evaluate whether combination groundwater dewatering and landfill gas extraction could be successfully employed to alleviate gas pressures and vinyl chloride concentrations. A groundwater extraction well was installed in January 2002 and a groundwater pump test was conducted in February 2002. The extraction well GEW-1 was installed approximately 10 ft north of gas monitoring probe GP-C. The pump test indicated that the silty sand soils were capable of only extremely low yields. Pumping well GEW-1 went dry after approximately two hours of pumping at a rate of approximately 0.5 gallon per minute (gpm). No drawdown was observed at gas probe GPC which is located approximately 10 ft from the pumping well. Due to the poor hydraulic connection to the W1/W2 unit, the pump test was repeated at existing well W17. This well pump test suggested a slightly greater radius of influence. Based on the drawdown analyses of the W1/W2 layer, STS proposed that a corrective action system consisting of combination groundwater dewatering and gas extraction wells be installed along the western perimeter of the landfill in the vicinity of G52S.

In late 2002, BFI contracted with Herst and Associates to permit and install the combination dewatering system along the western perimeter of the landfill. The passive vent corrective action system to alleviate the gas induced vinyl chloride concentrations was installed by Herst and Associates in early 2003. An evaluation of the system effectiveness was submitted to IEPA in July 2003. Additional corrective measures including combination groundwater dewatering and gas extraction wells PV-6 through PV-14 were installed in 2006. The dewatering wells lowered the water table such that the gas pressures were significantly reduced. The hydrostatic pressure exerted by the groundwater was also significantly reduced by the regional drought which occurred during 2005. Vinyl chloride concentrations at wells G52S and G131 decreased during 2005 and 2006. Vinyl chloride was not detected at either monitoring well G131 or G52 during any of the four quarters of monitoring conducted during 2007 or during the first quarter of 2008. The results of the west side corrective action efforts have been summarized in the annual corrective action evaluation which has been submitted by Herst and Associates in July of each calendar year.

Annual reports prepared by STS provide a summary of the landfill gas monitoring results at the landfill parameter monitoring probes. The data has been utilized to identify areas where gas migration has been detected. The results of the historical gas migration monitoring are summarized in the graphical analysis provided in Appendix D1. Pursuant to regulatory requirement, the facility initiated an active gas collection system within the landfill. Additional corrective measures were also implemented in the areas outside of the landfill footprint in order to mitigate the landfill gas migration. These corrective measures have included the Herst and Associates west slope corrective action described in the previous paragraph and the installation of passive vent wells along the southern perimeter of the landfill. Due to the relatively low hydraulic conductivity of the soils and the saturated soil conditions, the efforts to vent or extract gas have met with mixed success.

As shown in Appendix D, nested gas monitoring probes have historically been installed at approximately 11 locations around the perimeter of the landfill. These nested gas monitoring probes indicate that the gas migration has been largely restricted to the discontinuous unit referred to as the W1/W2 Interface (Bogner, 1988) typically found at elevations ranging between 740 ft MSL and 775 ft MSL. No landfill gas migration has been detected in gas probes completed within stratigraphically lower geologic units. Bogner (1988) indicates that these deeper till units were typically saturated. The historical monitoring results also indicate that the W1/W2 is variably saturated in the vicinity of the site. In areas where the sand seam is completely saturated, the groundwater can act as a barrier to gas migration. In other areas, fluctuating water table elevations may allow a vadose or unsaturated zone where gas migration can occur. The historical pressure monitoring results from the perimeter gas probes also indicate that the fluctuating water table may also exert a strong influence on the gas pressures detected in the gas probes.

In July 2006, Herst and Associates conducted an on-site investigation within the Forest Preserve District right of way between County Farm Road and the landfill. During the course of conducting the investigation, methane was encountered within the open borehole at location B-3 (refer to Drawing 4). Methane was not detected based on the screening of the other boring locations between the landfill and County Farm Road.

1.5 Administrative Order on Consent (AOC)

The detection of landfill gas in the right of way area to the west of the landfill prompted USEPA to initiate a review of the potential for landfill gas migration from the Mallard Lake Landfill. During the fall of 2007, several meetings were held between BFI, the FPDDC and the USEPA. Work plans were developed for an investigation of offsite areas located in Discovery Park and in the Forest Preserve right of way where the gas had previously been detected by Herst and Associates. On November 7, 2007, STS initiated an off-site cone penetrometer investigation of potential off-site gas migration within the Discovery Park area located west of the landfill. The study was initiated on behalf of BFI and the FPDDC. On November 8, 2007, landfill gas was encountered at probes CP-1, CP-2 and CP-4 which were installed in the southern portion of Discovery Park and at probes RW-3 and RW-4 within the Forest Preserve District right of way, and at boring RW-5 in the Hawk Hollow Preserve (refer to Drawing 4). USEPA and IEPA were notified that offsite gas migration had been detected. Additional characterization was conducted on November 9 and 10, 2007. However, the contractor (Stratigraphics) was not available for more than four days and could not complete the investigation. Another contractor (Fugro) was scheduled to complete the off-site investigation. However, this contractor was not available until early December 2007.

Based on the detection of landfill gas at the off-site locations in Discovery Park, the Forest Preserve right of way and at Hawk Hollow, BFI and the FPDDC decided to enter into a consent agreement with USEPA to investigate the extent of the landfill gas migration and to implement corrective measures to mitigate the off-site gas migration. A consent agreement between USEPA, BFI, and the FPDDC was signed on December 4, 2007. Work plans describing the proposed scope of work to investigate and remediate the gas migration were submitted to USEPA on December 6, 2007. An emergency action plan was submitted to USEPA on December 6, 2007 and a health and safety plan was submitted on December 11, 2007. ENSR Engineering, acting on behalf of STS, submitted a quality assurance project plan (QAPP) on December 19, 2007. Pursuant to USEPA's request, the investigations proceeded with USEPA approval prior to receipt of final comments on the work plan. STS, acting on behalf of BFI and the FPDDC, contracted Fugro Inc. to conduct a cone penetrometer evaluation of the off-site extent of landfill gas migration. A supplemental investigation began on December 5, 2007. A cone penetrometer rig was mobilized to the site from Houston, Texas. The cone penetrometer rig was utilized to characterize subsurface conditions and to install landfill gas monitoring probes which were used to determine the extent of the landfill gas migration.

2.0 Investigations – November 2007-March 2008

Offsite cone penetrometer studies were conducted to evaluate the potential extent of landfill gas migration where on-site gas monitoring probes had previously indicated the presence of combustible gas in excess of the 50% LEL regulatory requirement. As shown in Figure 1, four areas were investigated. These areas are summarized as follows :

- The west side investigation area extended from the landfill perimeter berm to approximately the Bartlett/Hanover Park municipal boundary to the west (refer to Drawing 4);
- The east side investigation area was initially established based on periodic gas probe detections at GP-IS and GPH. This area extended around the eastern perimeter of the landfill and into the Mallard Lake Forest Preserve (refer to Drawing 5);
- An investigation was conducted along the south side of the landfill to evaluate migration in the vicinity of gas probes E-1, P-6B and GP-2 (refer to Figure 3); and
- Finally, an investigation was conducted to evaluate the extent of migration in the vicinity of gas probe GP-E along the southeast corner all of the landfill (refer to Figure 4).

2.1 W1/W2 Unit Characterization

The primary investigation method for combustible gas and groundwater characterization of the W1/W2 unit was performed utilizing Cone Penetrometer (CPT) rigs from Stratigraphics, Inc. of Prophetstown, Illinois for Phase I of the investigation and Fugro Inc. of Houston, Texas for Phase II. Due to the depth of the W1/W2 and the stiffness of the overlying Wadsworth Formation diamictons (mainly glacial till) at the site, CPT rigs have a decided advantage in their ability to hydraulically penetrate the site soils to desired probe completion depths within the W1/W2. Because a CPT rig can generate tip pressures up to 2 million pounds per square foot they have previously been utilized to successfully penetrate through the W1/W2 unit (at depths ranging from approximately 50 to 70 ft bgs; at elevations of 740 to 775 ft MSL) in the areas surrounding the landfill. In addition to the hydraulic push advantages, the CPT rig enables electrical conductivity and pore pressure data to be viewed as the sounding is advanced providing a real time evaluation of landfill gas presence and pressures. Thus, the performance of the CPT equipment is believed to offer certain data collection and depth of penetration compared to other standard (Geoprobe™) sampling and probe installation methods.

Safety precautions were taken to address the potential landfill gas issues present in the investigation area. Personnel completing or observing the CPT investigation program were OSHA 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) trained. Additionally, air monitoring was conducted within the CPT rig using a Multi Rae detector equipped with a photoionization detector (PID), a combustible gas detector, an O_2 sensor, a hydrogen sulfide(H_2S) and a carbon monoxide (CO) detector. A Landtec GEM 500 Multiple Gas Analyzer capable of monitoring oxygen, carbon dioxide and methane was also utilized to monitor the open hole and the sealed gas probe concentrations.

2.1.1 Soil Point and Shear Resistance

Pressure sensitive cells located at the tip and along the sleeve of the probe were utilized to characterize the soil texture. Software developed utilizing the methodology presented by Robertson and Campanella 1983 was utilized to analyze the pressure cell data in order to correlate the data to the Unified Soil Classification System (USCS) designations. Figure 5 provides a nomograph depicting the soil textural interpretation based on the CPT data. This relationship is utilized to assess the data on fractional inch intervals so that a continuous record of the soil stratigraphic conditions was obtained over the length of the penetration. Previous CPT soundings at the site have correlated very well to physical soil sample data. CPT soundings were completed adjacent to continuously sampled soil borings completed by Herst and Associates (right of way Borings B-1, B-3 and B-4) in order to provide "ground truthing" to correlate the results to physical soil samples. The locations of these borings are shown in Drawing 4. Several other shallow borings were continuously or selectively sampled through discrete intervals to provide additional "ground truthing" at various areas throughout the off-site investigation area (i.e., CP-10I, CP-2I, CP-20 and CP-12D).

2.1.2 Electrical Conductivity (EC)
Electrical conductivity varies as a function of the soil texture (sand tends to be resistive or have a lower conductivity), degree of saturation and due to the presence of ions in the groundwater. Previous CPT soundings at the site have shown that the EC profile can be used to provide an indication of water and/or gas saturated zones in the soil. This information can be useful in defining any gas water interface which might exist within the soils. The data may also be utilized to identify high conductivity zones which might correlate to leachate impacts.

2.1.3 Piezometric Pressure Measurements
The CPT probe is equipped with a pressure transducer which is used to measure the generated soil pore water response to CPT penetration. The transducer also responds to the pressure generated by gas trapped within the soil. Thus, pore pressure dissipation tests conducted within the W1/W2 unit are used to evaluate the hydrostatic head and/or landfill gas pressure distribution within the soil. The hydrostatic pressure measurements were used to identify zones where the groundwater head in the W1/W2 acts as a barrier to gas migration. Finally, piezocone dissipation tests were conducted to evaluate how quickly the pore pressures induced by pushing the cone into the soil dissipate. The time required for the pressures to dissipate is directly related to the hydraulic conductivity of the soil. Permeable sand seams tend to equilibrate quickly, whereas clayey or silty intervals require greater periods of time for the induced pressures to dissipate. Thus, the dynamic pore pressure data was utilized to provide a qualitative indication of the texture of the penetrated soils.

2.1.4 Soil Gas and Groundwater Sampling
The CPT rig was utilized to install temporary monitoring probes/wells which were used to collect both soil gas and groundwater samples. A ¾ inch diameter schedule 40 PVC monitoring probe was installed into the W1/W2 unit in order to monitor groundwater quality and potential gas composition at each of the investigation locations. However, in locations where multiple granular zones were encountered at shallower depths, additional probes were screened in these shallower seams (i.e., CP-12, CP-30S, CP-33S and CP-35S). The locations of shallow probes were chosen in cooperation with the USEPA and Weston Solutions based on the CPT data suggesting coarse grained soil textures and the existence of thicker granular layers, evidence of gas pressures or methane and also the proximity to surrounding residences.

2.1.5 CPT Data Interpretation and Probe Installation Depth Determination
The CPT data was utilized in combination with existing boring data to develop stratigraphic interpretations both west and south of the landfill site. A limited offsite soil boring program was also conducted to better define the stratigraphy and to install gas monitoring probes in deeper stratigraphic locations. For instance, gas probes RW-1, RW-3 and RW-4 were installed in the Forest Preserve District right of way adjacent to soil borings B-1, B-3 and B-4 conducted by Herst and Associates. These borings provided geologic control and acted as a ground-truth to compare it to geologic soil descriptions to the cone penetrometer tests. Additionally, nested gas probes were installed at CP-12, CP-20D and RW-5, split spoon soil samples were collected from each of these borings to aid in geologic logging. As shown by comparisons of the boring logs and CPT test data presented in Appendix A, the CPT data generally provides good agreement with the soil boring log descriptions. Similarly, Fugro CPT test location GPT-1 was located in very close proximity to Stratigraphics test location CPT-2 which was completed in 1998. The Fugro test data must be adjusted for surface elevation changes which occurred after the placement of the final landfill cover and the associated re-grading around the landfill perimeter. These re-grading changes resulted in an increase in surface elevation at GPT-1 of approximately three ft. Otherwise, these CPT data from the two contractors appear very similar.

The geologic interpretation program included the construction of cross sections, a structure contour map of the W1/W2 and a map of the cumulative W1/W2 unit thickness. The data proved useful in evaluating the presence of coarser-grained deposits which may promote transport or function as stratigraphic traps where gas may have accumulated. The stratigraphic and piezometric data were also useful in identifying areas where the seasonally low piezometric surface occurs several feet above the top of the W1/W2 and thus acts as a barrier to combustible gas migration.

As mentioned above, the electrical conductivity and piezometric measurements were utilized to identify water and/or gas saturated areas and to measure gas pressures within the W1/W2. The program described above required that CPT sounding locations be penetrated twice. The CPT stratigraphy, electrical conductivity and piezometric measurements were conducted in conjunction with the first CPT sounding (refer to Appendix A for sounding logs). Subsequent to the initial sounding, drive casing was advanced through the open borehole to the desired probe installation depth. Once the desired depth had been reached, a sacrificial tip was knocked out of place and the probe was installed through the cased CPT hole. A detailed discussion of the probe installation procedures are described in Section 2.1.7.

Where the CPT rig was unable to either penetrate through the W1/W2 or install a probe at the desired depth a drill rig from Subsurface Exploration, Inc (SEI) of Libertyville, Illinois was utilized to complete probe installations. A total of four borings (i.e., CP-20D, CP-12D, CP-26, RW-5I) were completed using a wash rotary technique utilizing a 3 $^{7}/_{8}$ inch tricone bit. In instances where borings were completed deeper than the initial CPT sounding, the deeper portion of the borings was sampled continuously to provide a consistent stratigraphic record (i.e., CP-20D, etc.).

In addition, shallow nested probes at select locations were advanced utilizing a Geoprobe™ rig from Terra Trace Environmental Services of Lake Bluff, Illinois. Approximately 13 Geoprobe borings were completed at depths up to 40 ft below grade utilizing a 1 $^{7}/_{8}$ inch diameter direct push sampler. Geoprobe borings were sampled continuously to ground truth initial CPT soundings at each location (refer to boring logs presented in Appendix A). Samples were collected utilizing a 4 ft long split barrel sampler driven into the soil. After each successive push the sampler was retrieved and logged. Borehole termination depths were pre-determined pursuant to discussions between USEPA, Weston Solutions and the respondents.

Prior to conducting the field exploration program, the test locations were field located and marked using aerial photographs of the site. The CPT locations within the Village of Hanover Park right of way were pre-approved through the Village Engineer. The joint utility locate and excavating service (JULIE) was then contacted to locate subsurface utilities in the vicinity of the proposed CPT probe location. Following installation of the monitoring probes, the top of the protective casing and the top of the inside valve assembly (refer to Figure 5 for a surface completion diagram) elevations were surveyed to an accuracy of $\pm$ 0.01 ft while horizontal probe locations were surveyed to $\pm$ 0.1 ft by Weaver Boos of Naperville, IL. The survey data is referenced to the landfill coordinate system to allow correlation with existing site data.

2.1.6 Open Hole Gas Screening

Upon completion of the initial CPT sounding, the CPT hole headspace was monitored (CO_2, CH_4, O_2 and balance gas) using a Landtec GEM 500 Multiple Gas Analyzer. The gas concentration measurements were made soon after the CPT rod was removed from the hole. The analyzer probe intake was placed a minimum of 1 ft bgs (assuming that saturated conditions were not encountered). The CPT hole opening surrounding the gas analyzer hose was temporarily sealed around the gas analyzer hose using a plastic bag or rubber grommet. A ¾ inch monitoring probe was installed in the W1/W2 layer or at a stratigraphically similar interval if no W1/W2 unit could be defined at each location (refer to Section 2.1.7) regardless of the results of the open hole gas monitoring results. The open hole gas monitoring results were considered in combination with the cumulative CPT investigation results when locations for shallow nested monitoring probes were considered.

During the installation of selected shallow nested probes utilizing a Geoprobe™ rig, combustible gas readings were taken with a Landtec GEM 500 after each successive advancement of the borehole sampler, until the borehole terminus depth was reached. In doing so, zones of potential gas migration were evaluated on a cumulative thickness basis to identify specific depth intervals through which gas migration may occur. Open hole gas screening was not utilized during the advancement of boreholes completed using wash rotary techniques due to the presence of drilling fluids in the borehole suppressing any potential gas migration from the subsurface into the borehole.

2.1.7 Gas Probe/Temporary Well Installation Methods

Approximately 118 CPT soundings were completed throughout the investigation area on all sides of the landfill. The probe construction is summarized in Table 1. Each of the soundings was utilized to install a nominal ¾ inch diameter schedule 40 PVC temporary monitoring probe. CPT sounding data was utilized to assess the elevation of granular intervals, water table and whether landfill gas was present. This data was utilized to determine the well screen intervals for the probes. The probes were generally installed such that the screen intervals penetrated the W1/W2 unit through which groundwater or landfill gas might be transmitted. Based on this approach, the probes could be utilized to monitor for both groundwater and landfill gas migration. Similarly, the probes could also be utilized to monitor gas concentrations and pressures within the W1/W2 layer.

As previously discussed, the ¾ inch probes were installed through a nominal 2 inch outside diameter AQ size drill rods. Where possible, the rods were advanced through the initial CPT sounding borehole to the believed base of the W1/W2 unit using a sacrificial cone tip. Once the rods reached the desired depth, the rods were retracted to deploy the sacrificial tip and the ¾ in ID probe/well was installed through the casing. Approximately 1 to 2 gallons of potable water was added to the casing prior to removing the sacrificial tip in order to minimize gas intrusion and/or hydrostatic blow in of sand and silt deposits. Where possible, the probes were installed such that the screen interval intersected the complete thickness of the W1/W2 unit. Probes installed during the initial phase of the investigation (by Stratigraphics) were installed with 5 foot sections of 0.010 inch slotted screen covered with a geotextile filter fabric. Probes installed during phase II of the investigation were installed utilizing 1.5 inch diameter sand pre-packed 0.010 inch slotted well screens. The screen length used at a monitoring location was determined based on the thickness of the W1/W2 unit (i.e., 5 ft, 10 ft, etc.). As described above, the probes were generally installed within the hole created by the CPT testing tools. However, a total of five shallow nested probes were completed using the CPT rig to install the probe by directly pushing the drill casing to the desired screen interval elevations and deploying the sacrificial tip as described above (i.e., CP-30S, CP-33S, CP-35S, CP-42S and CP-60S).

The probe's annular space was sealed using bentonite packers (approximately 10 inches in length) placed at 10 ft vertical intervals above the well screen. The lowest packer was placed within a foot of the slotted screen interval, approximately one foot above the top of the W1/W2 layer. This typically resulted in approximately four packers be placed above the screen interval. The packers were hydrated with distilled water prior to retracting the well casing. Once the packers were allowed to hydrate for a minimum of at least 12 hours, the upper portion of the borehole was sealed using granular bentonite installed and hydrated from the ground surface (refer to Appendix B for well completion examples). Probe PVC riser pipe was sealed with a series of compression fittings and teflon taped threaded PVC couplers with a quick disconnect valve. The probes were then completed with a flush mount protector casing. Refer to Figure 5 for schematic diagram depicting the surface completion of the gas probes.

Selected nested probes installed using either Geoprobe™ or wash rotary techniques were completed using either 1 inch or 2 inch diameter schedule 40 PVC. A total of thirteen 1 inch and three 2 inch probes were installed (CP-26, CP-12D and RW-5I). Screen intervals within both diameter probes were constructed with 0.010 inch slotted screen surrounded by coarse grained silica sand filter pack. Screen intervals for shallow nested probes were determined based on the initial CPT sounding at each location and pursuant to discussions between USEPA and respondents. At one location (CP-20D), a ¾ inch diameter probe with a pre-packed screen was installed in a borehole advanced utilizing a 3 $^{7}/_{8}$ tricone bit due to a lack of 2 inch diameter well supplies. The pre-packed screen was then back-filled with additional silica sand and a bentonite pellet seal was placed above the sand pack. For probes not installed with the CPT rig, the remaining annular space above the lower bentonite pellet seal was then sealed with granular bentonite and hydrated from the surface with distilled water. The top fittings and surface completion were the same as described in the previous paragraph (refer to Figure 6). The probes were completed with a flush mount protector casing.

The locations and elevations of each of the CPT test locations were surveyed so that data collected during the investigation could be correlated to the on-site investigation data. The locations and elevations of the test locations were surveyed by Weaver Boos Inc. using a survey level to an elevation ± 0.01 ft. and a horizontal accuracy of 0.1 ft.

2.2 Gas Monitoring Methods

2.2.1 Field Monitoring of Gas Composition

Landfill gas is a biogas containing high percentages of both methane and carbon dioxide. The methane is typically generated in one of two ways: from the reduction of hydrogen with carbon dioxide or the direct cleavage of acetate into methane and carbon dioxide. The presence of oxygen and nitrogen in landfill gas indicates air intrusion into the gas extraction well or probe, or may be reflective of soil gas mixtures in shallow probes influenced by downward diffusion of atmospheric air. Oxygen is directly consumed by a variety of soil gas processes which produce carbon dioxide. Carbon dioxide processes in the subsurface and at the soil-atmosphere boundary are highly complex, including processes which produce carbon dioxide (methanogenesis; root zone respiration; direct oxidation of organic matter; methane oxidation by aerobic methanotrophs) and consume carbon dioxide (methanogenesis; photosynthesis). In addition, carbon dioxide is highly soluble so it can be readily partitioned to the aqueous phase in partially-saturated or fully-saturated sediments. This results in the formation of carbonic acid, which lowers the pH and promotes the further dissolution of available carbonates in sediments.

Monitoring for potential landfill gas constituents has been conducted throughout the investigation. Monitoring probe locations screened within the W1/W2 layer were monitored for the presence of potential landfill gas constituents within both the open borehole and after probes had been installed. Results of this monitoring, along with data from the initial CPT soundings were used to determine locations for additional shallow soil gas testing/probes and soil vapor volatile organic compound (VOC) constituent testing (i.e., summa canister monitoring). All gas monitoring was conducted utilizing a Landtec GEM 500 multiple gas meter for methane (CH_4) carbon dioxide and oxygen concentrations. The GEM 500 was calibrated daily utilizing CH_4, CO_2, and O_2 span gases.

Prior to sampling a probe, static pressure readings were recorded in inches of water pressure by attaching a quick disconnect fitting on the GEM 500 intake hose to an air tight fitting on the probe. After pressure readings were taken the well was purged with the GEM 500 until gas concentrations stabilized (provided the water level in the probe did not block the flow by blinding the well screen). All combustible gas concentrations and static pressures were recorded in a bound field notebook.

2.2.2 Soil Gas VOC Analyses

Based on results of the initial soil gas screening described in Section 2.2.1, individual probes were selected to undergo VOC analyses of the gas within the headspace of the probes. The probes undergoing headspace analyses were selected based on the presence of combustible gas. Summa canisters were provided by ConTest Analytical Laboratory of East Longmeadow, Massachusetts. Gas samples were analyzed for the presence of methane and major gases (CO_2, O_2 and N_2) utilizing USEPA method 3C and VOCs utilizing USEPA method TO-15. The 6 litre (L) summa canisters were shipped to the site under a vacuum of approximately -30 inches of mercury.

Regulators utilized with each of the canisters were pre-set to regulate airflow such that the sample was drawn over a period of approximately one hour. Individual canisters, regulators and tubing were assigned unique identification numbers which were utilized for each individual sample and recorded in a bound field notebook. Once the canister had been filled (i.e., canister pressure between 0 and -2 inches) the valve was closed and the regulator disconnected from the canister. The summa canister valve cover plug was re-installed and the canisters were boxed and shipped to the analytical laboratory, ConTest in East Longmeadow Massachusetts.

Monitoring locations for summa canister monitoring were selected pursuant to discussions and mutual agreement between USEPA, Weston Solutions and the respondents. The initial summa canister monitoring round consisted of six samples (i.e., CP-1, CP-2, CP-4, RW-3, RW-4 and RW-5) that were collected on November 26 and 27, 2007. These initial six summa canisters were collected from probes where landfill gas was detected within Discovery Park and the Forest Preserve right of way. The second round, consisting of 20 samples, was collected on February 22, 2008 from locations mutually agreed upon with USEPA (CP-14, CP-14 Dup, CP-16, CP-18, CP-20, CP-26, CP-29,

CP-32, CP-38, CP-40, CP-47, C-48, GP-E, P2C, GX-1, GX-9, GX-9 Dup, P-6B and RW-8). The analytical results for these summa canister analyses are provided in Appendix D-3. The final two summa canisters were collected on March 20, 2008 from the Utility Flare inlet (i.e., composite landfill gas sample) and from a sealed 10 ft long 4 inch diameter PVC casing containing the pressure transducer utilized to monitor probe GX-1 during the well TW-1 pump test. This pressure transducer was suspected to have cross contaminated probe GX-1 with perchloroethene since the transducer was recently utilized for a similar pump test conducted at a downstate site contaminated by this constituent.

2.2.3 Shallow Soil Gas Survey

USEPA has also requested the completion of a shallow soil gas survey around the residences and within Village right of way or parkway areas in front of the residences. To date, a total of 57 residents have requested a shallow soil gas survey of their property and a total of 8 have been completed. A survey consists of advancing a ¾" diameter probe approximately 2 ½ ft bgs, retracting the probe and taking a soil gas measurement utilizing the GEM 500 multiple gas meter. None of the shallow soil gas surveys completed to date have identified the presence of any landfill gas related constituents (refer to Appendix D-4). It should be noted that completion of shallow soil gas surveys are highly dependent on weather conditions. Extraordinary cold and excessive snow falls this winter have created an extremely thick frozen soil horizon and repeatedly covered up commercial utility markings. Additionally, many of the probes have encountered a very shallow water table which has resulted in the aspiration of water into the field gas meter instrumentation. As such, the shallow soil gas survey has been temporarily delayed until more conducive weather conditions exist.

When the survey resumes, it is anticipated that the shallow soil gas testing will consist of the following procedures:

> A 2 to 3 ft deep ¾ inch diameter pilot hole will be advanced into the soil using a slam bar to advance a steel probe (similar to a fence post driver). The slam bar will be retracted from the hole and replaced with a stainless steel sampling probe which is equipped with a plastic surface grommet and a polyethylene tubing sampling port. The tubing will be connected to the GEM 500 combustible gas detector to monitor for the presence of combustible gases. It is anticipated that one soil gas test will be completed along each side of the residential structure. The results of the monitoring will be noted in a bound field book along with a sketch depicting the sample collection locations.

2.2.4 Combustible Gas Monitoring of Sewer Manholes and Catch Basins

Sewers and catch basins in the US Homes subdivision and the subdivisions west of County Farm Road have been screened for the presence of potential landfill gases. Because the sewers are often located at depths of 8 to 10 ft below grade they are potentially more likely to intercept vertical migration of combustible gases before it would reach the elevation of the floor slabs of the adjacent structures. On Tuesday, November 27, 2007, the Village of Hanover Park Public Works Department and the Fire Department checked for the presence of methane gas in the sanitary sewer manholes located in the parkways in front of the following addresses:

1825 Whitney
1801 Whitney
4765 Whitney
4745 Whitney

The manholes were monitored using the Fire Department's four gas meters. Based on this screening, no combustible gases were detected in the sanitary sewer manholes.

Additional sewer manhole gas monitoring was conducted on December 7, 2007 by STS personnel at the following locations:

Southwest corner of Whitney Dr and DeForest Ln
Southwest corner of Whitney Dr and Howe Ln
East side of Howe Ln near 4625 Whitney Ln

North side of Whitney Dr near 1714 Whitney
South side of Whitney Dr near 1733 & 1741 Whitney
Between 1774 and 1752 Whitney Dr
Between 4534 and 4542 Whitney Dr
Between 4525 Whitney and vacant lot
Between 1753 and 1731 Zepplin Dr
Between 1763 and 1771 Howe Ln

As in the case of the Fire Department screening, no combustible gas concentrations were identified in any of the sewer catch basins that were screened (refer to Appendix F).

2.3 Groundwater Monitoring

2.3.1 Groundwater level monitoring

Groundwater levels were recorded from the temporary CPT monitoring probes on February 14, 15 and 16, 2008. It is anticipated that additional groundwater level monitoring events will be conducted once the snow has melted in the area. Pursuant to discussions with USEPA, the CPT monitoring probes were maintained in a sealed state to minimize the release of any landfill gas trapped in the formation. Therefore, the groundwater elevations were not equilibrated to atmospheric pressure conditions. As such, the groundwater elevations had to be calculated as a function of the total pressure which included:

The hydrostatic pressure;
The trapped gas pressure; and
The barometric pressure.

Due to the weather conditions which existed in mid-February, it was not possible to locate all of the monitoring probes or record water levels at each of the more than 130 probes within a single day. Prior to initializing the groundwater monitoring event the probes were located beneath the snow utilizing a metal detector and were dug out of the snow banks to improve access. The groundwater levels were measured utilizing an electronic water level indicator. Prior to opening the monitoring probe a headspace gas pressure measurement was made utilizing a magnehelic pressure gage. Once the headspace pressure measurement was completed, the probe was opened and the water level was measured to an accuracy of $\pm$ 0.01 ft utilizing an electronic water level meter. The groundwater elevation was then calculated by subtracting the water level from the surveyed top of casing elevation and adding the headspace gas pressure measurement. Finally, the readings were normalized to account for barometric pressure changes by subtracting or adding the relative change in barometric pressure from the time of the first water level measurement. The results of the water elevation monitoring program are presented in Appendix C.

2.3.2 Groundwater Quality Monitoring

Pursuant to discussions with USEPA, groundwater monitoring within the temporary probes has been conducted for field screening purposes to identify the nature and extent of potential VOC contamination within the groundwater. As such, the data quality objectives are not the same as might be utilized for other purposes (i.e., to demonstrate compliance with Groundwater Management Zone [GMZ] or compliance with maximum contaminant levels). Pursuant to discussions with USEPA, the use of temporary probes has been deemed appropriate for field screening purposes for the initial determination of the nature and extent characterization. Groundwater monitoring locations were selected pursuant to discussions between USEPA and respondents based on the status of the CPT investigation. An initial round of groundwater monitoring was completed during the week of November 26-30, 2007. The initial monitoring consisted of nine temporary probes installed November 7 through 10, 2007 (CP-2, CP-3, CP-5, CP-9, CP-11, CP-12, RW-4, RW-5 and trip blank). Refer to Appendix E for analytical results and Drawing 2 for locations of the probes that were sampled.

A second round of groundwater monitoring was completed from March 6-13, 2008 consisting of 21 locations representative of the west side investigation area. Pursuant to discussions with USEPA, a potentiometric surface map was constructed for the W1/W2 unit (refer to Figure 25) in order to provide a rationale for choosing the proposed groundwater monitoring locations. The potentiometric surface map was submitted to USEPA on February 29, 2008 along with a proposed monitoring plan. The plan proposed monitoring VOC concentrations at 16 probes located throughout the west investigation area. The proposed monitoring points included CP-12D, CP-18, CP-14, CP-26, CP-55, RW-4, RW-5, RW-6, RW-8, RW-26, CP-30S, CP-35, CP-20, CP-47, CP-28 and CP-33S. USEPA responded on March 4, 2008 and requested that probes CP-1, CP-2, CP-4, CP-12 and CP-38 also be monitored. STS, BFI and FPDDC agreed to attempt to monitor each of these probes. However, during the course of sampling it was determined that some of the probes contained insufficient volume of groundwater to collect these samples. For this reason, it was not possible to obtain groundwater samples from probes CP-1, CP-18 and CP-14. As such, groundwater samples were collected during the March 6-13, 2008 sampling round from the following probes:

CP-2;	CP-4;	CP-30;	CP-30 DUP
CP-12;	CP-12D;	CP-33S;	CP-35;
CP-15;	CP-19;	CP-38;	CP-47;
CP-26;	CP-28;	CP-55;	RW-26;
RW-4;	RW-4 DUP;	RW-4 (matrix Spike);	RW-5;
RW-6;	RW-8;	equipment blank 3/10/2008;	
equipment blank 3/11/2008;	trip blank 3/12/2008;	trip blank 3/13/2008.	

The results of the groundwater VOC monitoring at the CPT probes was used in combination with the landfill's on-site GMZ probe monitoring (i.e., probes GMP-13, GMP-14, GP-C) and the results of the groundwater detection monitoring to assess the need for an expanded offsite VOC probe monitoring program. Refer to Mallard Lake Landfill permit condition VII.24 for a more detailed discussion of the GMZ.

Pursuant to discussions with USEPA, two rounds of VOC monitoring were conducted at each of the designated, agreed upon monitoring probes where sufficient groundwater was present for sampling. Pursuant to previous discussions with USEPA, the probes need not be monitored more than twice if the initial two successive quarterly monitoring rounds do not indicate the presence of VOCs. Conversely, the probes will be monitored quarterly for at least four rounds if reportable VOC concentrations are identified. The groundwater monitoring program will be expanded to include surrounding probes if either of the initial two rounds of monitoring indicates the confirmed presence of VOCs. Based on the results of the initial rounds of the VOC monitoring, trace concentrations of VOCs were reported at several monitoring probes. As such, an additional round of VOC monitoring will be conducted in June 2008.

Prior to sampling the groundwater, the well/probes were purged to remove the stagnant water from the casing. If possible, the probes will be purged until field parameters (pH, specific conductance and turbidity) stabilize. However, many of the probes provide low well yield, the probes were purged until dry and then sampled after the water level has sufficiently recovered to allow collection of samples. A minimum of one probe volume of water was removed from slow recovering temporary wells (i.e., from probes that are purged dry). This occasionally required that the sampling be conducted over a multiple day period (purged on one day and sampled on the next). As in the case of the faster recovering wells, the pH, specific conductance and turbidity of the groundwater was recorded at frequent intervals during the well purging to document the degree of geochemical stabilization prior to collecting the groundwater samples.

STS attempted to sample the monitoring probes using a mechanical bladder pump (Geoprobe Model MBP 470) capable of sampling the ¾ inch diameter wells at these depths. However, due to low hydraulic conductivity and minimal hydrostatic pressures, the bladder pump was not capable of retrieving sufficient sample volume at each well location. As discussed in the work plan dated December 6, 2007, a small diameter bailer was used to retrieve the required sample volume. As discussed with USEPA, a bailer will be used as a first line sampling alternative. As required by the work plan, efforts were made to minimize well agitation and water table disturbance during the course of sampling. Furthermore, quality control samples (sample blanks) were collected using these alternate sample devices. Pursuant to discussions during the October 30, 2007 meeting with USEPA, an attempt was made to purge sufficient water to record field parameters (pH, specific conductance and turbidity) to document the well development and pre-sample purge. Insufficient flow was available to record the field parameter concentrations within a flow through cell to document well development/purging prior to obtaining the sample. Therefore, the purging was documented by samples taken at discrete time intervals during the purging.

The groundwater samples were transferred directly from the bailer into laboratory supplied glassware (VOA vials). The VOA vials were filled and sealed without the presence of headspace (bubbles). The samples were stored on ice until shipped to the laboratory under chain-of-custody on a daily basis. With the exception of monitoring probe CP-12D, the groundwater samples were shipped to Heritage Laboratories LLC of Indianapolis, IN for analysis of volatile organic constituents using SW 846 Method 8260B. Monitoring probe CP-12D was sampled on March 24, 2008. In order to guarantee that the results of the analyses from this probe were available in time for inclusion into this report, the analyses were conducted by First Environmental of Naperville, Illinois. Monitoring probe CP-12D could not be sampled during the March 6-13, 2008 period since the surface casing was not accessible and driller efforts to improve the access introduced PVC glue on the well riser pipe casing.

Pursuant to the requirements of the facility's Section VII Solid Waste Permit and 35 IAC 811.320, the applicable action levels outside the ZOA compliance point are background levels. Pursuant to the facility's permit background for VOC constituents are the practical quantitation limits (PQLs) stated by SW846 Method 8260B. Should confirmed VOC concentrations attributed to the landfill exceed the PQL levels, then a plan to contain or treat the contaminated groundwater will be developed.

2.4 Shut-In Tests

As discussed in the project work plan, it was anticipated that gas shut-in tests would be conducted on at least three probes which exhibited positive gas pressures. The tests were intended to evaluate the time required for the gas pressures to build once a probe has been fully or partially vented to atmospheric conditions. The Gas Technology Institute (GTI) indicated that the volume of gas present in the formation and the formation permeability may be estimated based on the shut in pressures, the volume of gas vented, the hydrostatic groundwater pressures (i.e., groundwater elevations) and time required for the probe to equilibrate once it has been sealed after having been vented to atmospheric conditions (Ibrahim S. Nashawi, Ahmed A. Elgibaly and Reyadha Almehaideb, 1998). It was also anticipated that the pressure response to the shut-in tests would also be monitored at adjacent probes in order to evaluate the degree of hydraulic and pneumatic connection within the unit. STS had proposed that the probe testing would be determined based on the static pressure and groundwater elevation monitoring. The data from each of the shut-in tests was going to be evaluated to estimate the volume of gas remaining in the W1/W2 unit and the pneumatic continuity of the gas. However, to date, no shut-in tests have been conducted due to the need to address appropriate air venting emission standards. A similar type of pilot test is currently being conducted at gas probes GPE and GX-9 along the southeastern margin of the landfill. Due to the proximity to the site infrastructure (gas collection system), the gas from the venting probes is being collected and conveyed to the landfill gas management system. However, the test has not been completed and the data has not been evaluated for purposes of estimating the hydraulic and pneumatic conductivity of the formation. It is anticipated that this testing program will be further evaluated at other probes following resolution of the air and emission requirements.

2.5 Radius of Influence Testing

2.5.1 TW-1 Pump Test Well Installation

A large diameter test well (TW-1) was installed on December 14, 2007 by Meadows Equipment of Carol Stream, IL at a location roughly equidistant from the P6 probe nest, GX-1 and GP-2 (refer to Figure 2). This well was installed as part of a corrective action work scope that preceded the AOC. This area was chosen because of the high probability that the sand thickness of the W1/W2 unit was at least several feet thick based on previous boring and CPT logs. TW-1 was advanced using water rotary drilling techniques to minimize "smearing" of soft clay across the sand unit to minimize head loss across the well. TW-1 was advanced to a depth of approximately 54.2 ft bgs using a 12-inch diameter drill bit. No subsurface samples were collected, but observations of the drilling rod vibrations during advancement of the drill bit (i.e., "chatter"), which sometimes can be correlated to harder lithologic units, were observed at depths of 40.0 to 44.8 ft. bgs. The W1/W2 unit is therefore estimated to be found between elevations of 758.3 and 763.1 ft MSL.

Upon termination of the borehole, a 6-inch diameter Schedule 40 PVC well with a 15-ft screen was installed at the boring terminus so that the screened interval was between 750 and 765 ft MSL. Coarse silica sand was placed in the annular space of the well to an approximate depth of 35.1 ft bgs which was about 3 ft above the top of the well screen. Approximately 12 ft of bentonite pellets was then placed over the filter pack and was allowed to hydrate overnight. The remaining annular space was backfilled with a high solids bentonite grout that was installed using a tremie pipe. Additional granular bentonite was added from the ground surface in order to compensate for settlement. The top of the well was sealed using an expandable compression fitting top. A protective casing was not installed at the time of installation because of the likelihood that the wellhead would be modified during the pump/vapor extraction testing or remedial system installation.

The newly installed test well was developed on December 14 and 17, 2007 by jetting water into the screen interval and then pumping the water from the well. The process of jetting and pumping the well was completed numerous times over an approximately 12 hour long period. Several hundred gallons of water were purged from the well using a submersible pump. Meadows Equipment continued the well development until the visible turbidity levels had been substantially eliminated. A groundwater sample was collected from TW-1 on January 24, 2008 and submitted to First Environmental Laboratories for analysis of indicator constituents (specific conductance, TDS, chloride, etc.) and method 8260 VOCs. Although laboratory results indicated that no VOC constituents were present above detection limits, nor were elevated concentrations of leachate indicator constituents detected, the USEPA requested that all purge water emanating from well TW-1 during the pump testing be contained and treated. As such, the pump test water was contained in a 400 gallon polyethylene storage tank and was transported to the leachate conveyance lift station via a flatbed truck.

The monitoring well TW-1 pump test was initially anticipated to consist of two parts. A groundwater pump test would be conducted to assess the aquifer transmissivity, the well yield and the ability to depress the groundwater to create a vadose zone which could then be used for vapor extraction. During the second part of the test, STS was going to mobilize a regenerative blower system to the site which could then be utilized to extract gas from the well once the vadose zone had been created. The groundwater discharge portion of the pump test at TW-1 was initiated on February 8, 2008 when vented LevelTroll transducers were sealed into TW-1, GP-2, GX-1 and P6A to record antecedent ground water level conditions (refer to Figure 3 for probe locations). Pumping at TW-1 was initiated on February 13 at 4:26 pm

Pursuant to the USEPA request, monitoring instruments were sealed in the probes to minimize the potential leakage of landfill gas to the atmosphere. Vented LevelTrolls were sealed in the gas probes using rubber grommets. Absolute LevelTrolls, which are not vented to the atmosphere, were sealed into the wellhead by extending the PVC riser pipe or temporarily replacing the PVC compression fitting with a wider diameter air tight fitting to allow the LevelTroll to be hung in the probe head space. The unvented LevelTrolls were deployed on February 13, 2008 prior to the initiation of pumping to monitor changes in groundwater levels and head space pressures in GX-2 and GX-5 through GX-7. Two unvented BaroTrolls were also placed at the facility to record barometric pressure. The second barometer was used to verify results and provided a safeguard in case of malfunction of the first instrument. Due to the lack of saturated thickness within P-6B (less than 1-foot of water), a transducer was not placed in the saturated zone of the well. Instead, water levels were recorded at P-6B manually using an electronic measuring tape. The summary field measurements taken during the TW-1 radius of influence pump test are included in Appendix H.

As shown on Table 2, gas measurements were taken from the head space of each of the observation wells using a Landtec GEM-500 or GA-90 except for probes GP-2 and GX-2. Several wells did not have any methane detected throughout the ROI test and therefore have not been summarized. The wells without methane detections include P-6A, GX-2, GX-5, GX-6 and GX-7. Methane was detected at TW-1, P-6B and GX-1, however methane concentrations dropped during the course of the test. Head space methane concentrations at P-6B increased slightly before dropping to below initial readings prior to completion of pump test.

The pump test methods are summarized as follows:

- The instruments (transducers and pump) were sealed in the probes and wells;
- Periodic gas measurements were taken during the course of the test;
- Constant rate pumping was not possible due to difficultly adjusting to flow rates at such low discharge (0.3 gpm). Therefore, the test sought to maintain a constant head equilibrium pumping rate;
- A bottom filling QED Hammerhead pump was used to maintain the water level in the well at a constant head;
- The QED Hammerhead pump was run using compressed nitrogen cylinders to limit the need to extend air lines to the well and in order to limit potential well gas emissions to atmosphere;
- The discharge water was collected in a 400 gallon poly tank on top of flatbed truck and was dumped in leachate riser L401. Approximately 925 gallons was purged over the 48.5 hr test (an average discharge rate of 0.3 gpm)

Tremendous efforts were required to run the pump test under sub-freezing conditions. The well TW-1 wellhead was wrapped in blankets. The discharge line was wrapped with an electrical line heater and then insulated. The poly tank was wrapped in blankets and equipped with a trough heater. Despite these efforts, the pump test discharge line still froze within the well casing. This resulted in a premature termination to the pump test. The test was run from February 13, 2008 at 16:26 to February 15, 2008 where pumping rates started to decrease at approximately 17:05. During the 48 hour test period, a near constant discharge rate was maintained at around 0.3 gpm.

Results for the TW-1 radius of influence testing are unique in that several assumptions that are made for solving traditional pump tests are invalid for this particular test. For instance, pump tests are traditionally run at constant discharge rates and analyzed using solutions which assume infinite aerial extent of a homogeneous and uniform thick aquifer. The TW-1 pump test was conducted as a constant head test since the low production rate (~0.3 gpm) of the production well would have been extremely difficult to pump at a constant rate especially for a long duration. Instead, a Hammerhead pneumatic pump was used to maintain a constant head below the bottom of the W1/W2 unit to create a cone of depression and evaluate the radius of influence of the test well. The granular units which comprise the W1/W2 unit are stratigraphically isolated, discontinuous with limited areal extent and vary significantly in thickness texture and uniformity.

In addition, the TW-1 pump test was unique because nearly all of the instruments were sealed within the observation wells to minimize the potential for leakage of landfill gases to the atmosphere pursuant to USEPA requests. This is unique in that the head space of each of the wells had to be continuously monitored separately to differentially correct instruments that were placed below the water table. The following equation was used to evaluate the water level data collected using absolute pressure transducers during the TW-1 pump test:

$$\begin{array}{rl} & \text{Total Pressure of Instrument in Water} \\ - & \underline{\text{Total Pressure of Instrument in Head Space}} \\ & \text{Head on Instrument in Water} \end{array}$$

The head on the instrument was then utilized to calculate a groundwater elevation by determining the elevation of the instrument using the static groundwater level and added the head pressure (in feet) to the instrument elevation. Vented LevelTrolls placed in P6A, GP-2, GX-2 and TW-1 was not differentially corrected because they are equipped with vent tubes which are equilibrated to atmospheric conditions.

Another complicating factor in analyzing the TW-1 pump data was that water level recovery data from the test could not be used for analysis of hydraulic conductivity and storativity because the aquifer was allowed to slowly recover when the discharge line slowly froze. When the line was freezing, pumping rates decreased and water levels recovered until discharge stopped completely. This was unfortunate given the efforts to weatherize the discharge line and water storage tank. In any event, the premature termination of the drawdown test and the loss of recovery test limited the ability to interpret the data. However, the TW-1 pump test yielded enough data to qualitatively make several inferences on the dynamics of W1/W2 within the Wadsworth Formation in the TW-1 investigation area.

The TW-1 pump test results are summarized on several figures and tables which are included in Appendix H. Several data sources were used to assess the TW-1 pump test. These data sources include the following:

- A summary of field measurements including ground water quality parameters of the discharge water, manual water levels readings at P-6B, as well as gas concentration readings of the observation well head spaces using a Landtec GEM-500 or GA-90,
- A hydrograph of the pumping well and observation wells showing antecedent monitoring, pump test levels, recovery and post test monitoring,
- Barometric and temperature readings taken onsite during the test,
- Graphs of drawdown vs. time at wells with observed changes from static conditions,
- Normalized plots of drawdown vs. time to evaluate relative changes in individual observation points, and
- A detailed graph of GX-1 drawdown vs. time and head space gas readings.

Antecedent monitoring indicated static ground water conditions at the start of the pump test ranged in elevation from 761.5 to 763.5 ft MSL. The lone anomaly was GP-2 whose static water level was approximately 8 feet greater at an elevation of 771 ft MSL. After 8 hours of pumping, the maximum drawdown within TW-1 was reached. Approximately 9 feet of drawdown was observed in the pumping well and was maintained at an approximate elevation of 753 ft MSL throughout the remainder of the test. As previously mentioned, the W1/W2 layer at TW-1 is suspected to be from 758.3 and 763.1 ft MSL, so the water level in the pumping well was maintained well below the bottom of the W1/W2 unit so that it was completely dewatered during the test.

Several other wells, including GX-1, GP-2, GX-6 and GX-5, were also found to have observed drawdown. As shown on the semi-log graph of drawdown vs. elapsed time from pumping in Appendix Figure H-1, drawdowns from static conditions ranged from 1 ft at GP-2 to 0.40 ft at GX-1 and GX-6. Probe GX-5 was observed to have a maximum drawdown of approximately 0.5 ft. Other monitoring points such as P6B, GX-2 and GX-7 did not appear to have measurable drawdown or had indistinguishable results. Gas probe P6A also did not record measurable drawdown, but after inspection of the well installation details, it was found that bridging occurred during the placement of the gravel pack which resulted in a much larger screened interval. Because of the long screened interval between 20 and 60 feet below ground surface, water level data collected from P6A were not used. In addition, no methane was detected at P6A, so head space readings were also ignored.

The observed drawdowns are not intuitive considering a typical cone of depression where increased drawdown is observed closer to the extraction point, but the data collected at TW-1 must rather be considered in the context of the W1/W2 unit's varied composition and discontinuous nature. The pressure reduction in the W1/W2 unit caused by the lowering of the piezometric surface propagated quickly outward within the highest permeable materials in the W1/W2 unit. The data confirms that a hydraulic connection is present between TW-1 and GX-1, GP-2, as well as GX-5 and GX-6 as represented on geologic cross-section I-I'. However, lower permeable materials must be present near GX-1 because less of an influence due to pumping was observed.

Based on the reduction of methane, carbon dioxide and increase of oxygen levels taken during the test at GX-1, it appears that a vadose zone was developed substantially enough to reduce landfill gas concentrations. Landfill gas concentrations for GX-1, which are presented as a function of drawdown in Appendix Figure H-2, show a reduction in methane and carbon dioxide throughout most of the test. Therefore, extraction wells used to reduce piezometric heads used in conjunction with a vapor extraction system to remove landfill gas appears to be a viable option for remediation.

Discharge water from TW-1 was also monitored periodically for water quality indicator parameters so that data would be available for documentation of future remedial options such as recirculation of groundwater. As shown in Table 2, discharge water consistently showed a reduction in conductivity along with a slight increase in pH. Turbidity and temperature maintained consistent levels considering the cold temperatures in which the test was conducted. These results do not suggest leachate infiltration has occurred in the TW-1 vicinity.

During post-test monitoring, the onsite BaroTrolls monitored a large drop in barometric pressure on February 17. The drop of over 30 mmHg (or > 0.5 psi) within a 24-hour period resulted in large ground water fluctuations for wells screened within the W1/W2 unit. An approximate average of a foot or in the case of GX-5, greater than 2 feet of groundwater elevation fluctuations were observed in the observation points. Atmospheric pressures changes appear to be a very effective way of changing hydraulic heads within this confined unit.

To summarize, the south side radius of influence test was conducted at very low pumping rates (~0.3 gpm) suggesting the boring log for P-6 overestimates the thickness, sand content and hydraulic conductivity of the W1/W2 unit. The actual W1/W2 unit texture at P-6 likely contains thinner sequences of finer material that result in lower conductivity. Hydraulic changes in the piezometric surface can propagate quickly through the confined aquifer by using dewatering wells. In addition, landfill gas concentrations can be altered due to even minor groundwater level changes. Discharge water from the TW-1 production well was shown not to be influenced by the landfill and should considered for possible recirculation for remedial options.

2.5.2 Existing West Side Remedial Action Radius of Influence Testing

The performance testing of the west side corrective action system was evaluated during a two phase testing program. The phase 1 portion of the program consisted of isolating each of the extraction wells and observing the pressure dissipation and gas concentrations after the well was sealed off. Well pressures that dissipated quickly with the increasing methane concentrations were deemed to be connected to the gas migration zone. Conversely, wells that indicated the loss of all vacuum with decreasing gas methane concentrations, suggested intrusion of atmospheric air (i.e., increasing oxygen and nitrogen concentrations). This response was deemed to be indicative of short-circuiting to the atmosphere. Wells which exhibited evidence of short-circuiting were inspected to determine potential sources of leakage (i.e., crack casings, poorly sealed joints, screen intervals across several geologic horizons, etc.). Wells which indicated very little change in either pressure or gas composition were potentially indicative of watered in screen intervals. The performance data from each of the phase 1 evaluations of the passive vent of wells was tabulated and is presented in Table 3. The phase 1 evaluation also reviewed any available photographs or documentation for the header system connecting the past event wells. BFI pumped out the condensate sump located near passive vent well PV6. However, removal of the liquids from the sump did not appreciably affect the pressure distribution within the header system.

The phase 2 evaluation of the corrective action system consisted of conducting a radius of influence test for each of the wells believed to be functioning (i.e., wells receiving gas recharge from the W1/W2 zone) based on the results of the phase 1 testing program. This testing program consisted of deploying pressure transducers to gas monitoring probes located in the area surrounding the perimeter gas extraction wells. The observation probes were selected such that they were located at varying distances ranging from a few tens of feet to hundreds of feet from the gas extraction well. Initially, the system operation was altered by isolating the well of interest by closing the valves to the header. This resulted in elimination of the vacuum from these wells. The pressure response at the surrounding gas monitoring probes was then reviewed utilizing the pressure transducers and from gas pressure and concentration measurements taken using the GEM 500 multiple gas meter. In general, at least 1.5 hours was allowed for any pressure changes to be manifested in the observation probes. After monitoring the pressure dissipation after the well was shut down, the response was also monitored when the valves to the well were reopened, re-establishing the vacuum to the extraction wells. Again, the pressure response at each of the observation probes was monitored and reviewed graphically to determine if any pressure response existed. Similarly the methane, carbon dioxide, oxygen and nitrogen concentrations were also reviewed to determine whether the probes were being influenced by the variations in gas extraction well operation. These procedures were repeated for each of the extraction wells which were deemed to be functioning (i.e., wells PV-6, PV-7, PV-8 and PV-14 - refer to Drawing 2). The results of the radius of influence testing are presented in Appendix G.

2.6 Residential Screening and Combustible Gas Detector Installation

Although landfill gas was detected at depths greater that 25 ft, the proximity of residences to the CPT probes where landfill gas was detected prompted several additional screenings. These actions included the following:

- The monitoring of area residences for combustible gas and VOCs via field instruments;
- The installation of combustible gas detectors in the homes of residents near the gas migration area;
- The installation and monitoring of shallow gas monitoring probes to detect potential vertical movement of the gas (refer to section 2.2.3); and
- The monitoring of combustible gas within storm and sanitary sewers located within the residential areas (refer to section 2.2 .4).

Additional tasks are also planned to further evaluate the potential vertical migration of landfill gas toward area residences. These tasks are:

- Conducting additional shallow soil gas investigations to evaluate the potential presence of combustible gas in the shallow soils adjacent to the residences;
- Installing and monitoring sub-slab port monitoring devices within the homes of residents which authorize such testing; and
- Monitoring sub-slab ports for the presence of combustible gases and/or VOCs

Each of the tasks which are in the process of being completed or will be completed in the near future are discussed below.

2.6.1 Monitoring of Area Residences for Combustible Gas and VOCs

On Saturday, November 17, 2007, USEPA initiated the monitoring of homes in the area of the detected gas migration. This monitoring was conducted using an organic vapor analyzer (TVA 1000) which enabled indoor air quality to be monitored by both flame ionization detector (FID) and photoionization detector (PID). The concentrations of carbon monoxide in the homes were also monitored using a MultiRae Plus Detector Model No. PGM 50-5P. On November 19, 20, 21 and 23, 2007, STS accompanied the USEPA and monitored the indoor air quality using a MultiRae Plus four gas meter which was also equipped with a PID. The MultiRae was used to monitor the following gases:

Combustible gas as a percent of the Lower Explosive Limit (LEL) (calibrated to methane);
Carbon monoxide;
Hydrogen sulfide;
Oxygen; and
Presence of VOCs by PID

To date, the home monitoring for combustible gases has not detected the presence of methane attributable to the landfill. Initially, the monitoring survey was conducted on a door to door basis in the vicinity of the gas migration area. USEPA explained the objectives of the monitoring program to the residents and then requested access to the premises to monitor the air quality. Later the home monitoring program was conducted on a scheduled appointment basis.

Within the US Homes subdivision west of the landfill, the following locations within the home were generally monitored when access was granted:

Kitchen breathing zone;
Living room breathing zone;
Laundry, furnace, hot water tank area breathing zone; and
Laundry, furnace, hot water tank area floor drain

Homes along County Farm Road and in the Mallard Lake Estates Subdivision located south of the landfill were monitored in the basements near the following locations:

Floor drains;
Foundation drain sump areas;
Sanitary sump areas;
Around pipe entry points into the basement (where apparent); and
In the breathing zone in various living areas of the home (i.e., kitchen, living room, etc.).

The results of this screening program are presented in Appendix F.

2.6.2 Combustible Gas Detector Installation

As discussed in the previous section, combustible gas detector installation began on November 26, 2007 within the residences in the vicinity of the combustible gas migration area. As of March 24, 2008, a total of 215 gas meters had been installed and nearly 250 properties have been screened for the presence of combustible gases. Due to commercial availability constraints, two different combustible gas detectors are being installed. The CCI Controls Model 7550 was installed in about 22 homes while the remaining detectors installed were Safe-T-Alert models. Additional meters will be acquired as necessary to respond to resident's requests for installation of the meters. The primary difference between the units is that the CCI model is equipped with a battery backup.

The meters which are being installed include the following features:

- UL Listed as a residential gas detector
- 10-hour backup system from two AA batteries (Model 7550 only)
- Proven tin dioxide sensor technology
- Use standard household current 120 VAC
- Easy and simple installation
- Convenient six foot power cord
- Self-test functions
- Four indicator lights convey alarm's status
- Five year limited warranty
- Alarm output 85 decibels
- Dimensions: 3.5" x 7" x 1.625"
- Mounting options: Direct to wall, on wall or flat surface
- Covers approximately 100 sq. ft area.

The User Manuals for both of these meters are provided in Appendix F.

2.7 Data Interpretation and Analysis

Data from the offsite CPT tests at Discovery Park, the Village right of way, the Schick Road right of way, the Forest Preserve District right of way (including Hawk Hollow) and the Village parkway areas have been used to evaluate the stratigraphic conditions and the extent of gas migration. The data review is presented in the form of the geologic cross sections, structure contour maps of the W1/W2 layer and the isopach maps of the W1/W2 layer thickness. The CPT characterization data were also utilized to delineate texture changes in the soils which were used to evaluate the presence of coarser-grained deposits which might influence transport. The data were also assessed to identify stratigraphic traps where gas may have accumulated. The stratigraphic and piezometric data was used to identify areas where the seasonally low piezometric surface occurs several feet above the top of the sand layer forming a potential barrier to gas migration.

The data were used in combination with on-site gas probe measurements to assess the extent of the gas migration. Piezometric data from the W1/W2 layer was recorded to document the presence of natural barriers (i.e., low hydraulic conductivity areas, saturated intervals, etc.) which act to limit the extent of landfill gas migration. A discussion of the results of the investigation is presented in Section 3 of this report.

3.0 Results of the Investigation

3.1 Results of Historical On-site Gas Probe Monitoring

The Mallard Lake Landfill gas migration presents complex issues. The Illinois solid waste regulations generally anticipate that the most common landfill gas migration pathways will be limited to the vadose or unsaturated zone. For instance, 35 IAC 811.310(b)(2) indicates that:

> "gas monitoring devices shall be placed around the unit at locations and elevations capable of detecting migrating gas from the ground surface to the lowest elevation of the liner system or the top elevation of the groundwater, whichever is higher."

Based on review of nested monitoring probes data, the groundwater elevations within the Wadsworth Formation typically occur within a few feet of the ground surface. Thus, pursuant to the regulatory guidance, monitoring probes would not be anticipated to be necessary due to the presence of saturated conditions at relatively shallow depths. However, hydraulic conductivity contrasts and variable groundwater recharge rates can result in a saturated or variably saturated granular zones at depth (i.e., the W1/W2 layer). These zones have been shown to contribute to gas migration

In areas where the W1/W2 layer is saturated, the landfill gas is less likely to migrate than where gas is present within the vadose or unsaturated zone. For offsite migration to occur within variable saturated portions of the W1/W2 unit, one or more of the following conditions must occur:

- The gas pressures must increase to levels greater than the hydrostatic pressures in order to displace the groundwater; or
- The gas may migrate if groundwater table fluctuations result in a decrease of hydrostatic pressures to levels which either create unsaturated conditions within the sand layer or reduce the hydrostatic forces allowing the groundwater to be displaced by the gas; or
- The gas may solubilize (go into solution) and migrate with the groundwater via advective or diffusion transport mechanisms. The horizontal component of the shallow groundwater flow appears to be toward the eastern and northern portions of the landfill where the leachate collection sumps are completed below the sand seam elevation. Vertical flow downward is likely to be impeded by the relatively low vertical hydraulic conductivity of the Wadsworth Till Unit. Furthermore, carbon dioxide is many times more soluble than methane, thus significant concentrations of methane are not likely to enter solution versus carbon dioxide. The aqueous diffusion coefficients for landfill gas components are four orders of magnitude lower than the gaseous diffusion coefficients, thus the potential migration of these constituents within the groundwater system (i.e., below the water table) via diffusion is extremely limited.

As such, the potential for significant gas migration within the aqueous phase (i.e., groundwater) appears very limited. For this reason, the landfill gas monitoring network has focused on unsaturated or seasonally saturated granular horizons within the Wadsworth Formation.

3.1.1 Description of Gas Monitoring Program

BFI monitors the landfill gas at the Mallard Lake Landfill in accordance with the requirements of 35 IAC 811.310. The monitoring conditions are presented in Section VIII of Modification No. 31 of Permit No. 1997-223-LFM and are described in greater detail within Section 11.4 of Addendum No. 3 to the Significant Permit Modification Application dated November 30, 1998 (Log No. 1997-223). The gas monitoring program entails monitoring subsurface perimeter probes located around the perimeter of the landfill, monitoring ambient air stations and continuous monitoring of site buildings.

Landfill gas is monitored at 60 onsite probes and 4 ambient air monitoring devices located around the perimeter of the landfill (refer to Drawing 3 for an Environmental Monitoring Plan depicting the locations of the gas monitoring probes). Pursuant to the monitoring requirements detailed in Section 11.4 of Addendum No. 3 to the Significant Permit Modification Application dated November 30, 1998 (Log No. 1997-223), the landfill perimeter probes are required to be monitored on either a quarterly and/or a monthly frequency depending on the past history of combustible gas detection. Probes at which combustible gas levels have been previously detected are required to be monitored on a monthly frequency, whereas, the remaining probes may be monitored on a quarterly frequency.

The monitoring program is summarized in Table 11-7 of Significant Permit Modification Addendum No. 3 (presented in Appendix D1). During 2006, each of the 59 gas monitoring probes was monitored on a monthly frequency (refer to Appendix D1 for tabular summary of the monitoring results). Pursuant to permit condition VIII.2, the subsurface probe monitoring is conducted for pressure, combustible gases (% methane), carbon dioxide and oxygen.

3.1.2 Results of Historical Landfill Gas Monitoring at On-site Probes

Time trend graphical plots for methane, oxygen and carbon dioxide and balance gas (100% - [V% CH_4 + V% CO_2 + V% O_2]) concentrations at the perimeter probes are presented in Appendix D1. Reportable levels of landfill gas (>2.5% methane) have been reported at approximately 25% of the monitored probes (15 locations) on at least one occasion during 2007 (refer to shaded probe locations designated in Appendix D1). Positive pressures greater than 1 inch of water were encountered at 9 of the 15 locations where gas was detected. Furthermore, since many of the static pressures are measured within the confined W1/W2 unit, which is variably saturated, the static pressures may vary in response to barometric pressure changes and water table fluctuations as well as the presence of landfill gas. Therefore, care must be used in interpreting the static pressure data. Positive gas pressures (greater than 1.0 inch H_2O) accompanied by elevated methane levels have historically been recorded most consistently at probes GP-C, GP-E, GP-H, GP-U, GMP-13, GMP-14, GMP-15, GMP-17 and P-6B. However, probes in the vicinity of the west side perimeter collection system (i.e., GMP-13, GMP-14, GMP-15) have indicated marked decreases in the gas pressure (in some instances the pressures have decreased by 100 inches of water column or more). The gas pressure decrease in this area is attributed primarily to depression of the groundwater table due to the perimeter collection system operation (i.e. dewatering being conducted at Herst corrective action wells). The extreme gas pressures (100 inches or more) previously observed are attributed to hydrostatic pressure acting on the gas trapped in the confined sand seam.

Probes GP-IS and GP-ID located along the east side of the landfill have indicated a pronounced decrease in methane levels over the past several years. In the past couple of years, methane and carbon dioxide levels have been seasonally high in the October through January period, but low or not detectable in the remaining months. During 2007, the gas concentrations at probe GP-IS increased slightly during the fall, but generally remained in compliance with 50% LEL requirement. Only one exceedance was observed at GP-IS. During November 2007, a methane concentration of 2.7% or 54% LEL was observed. This potential exceedance was not confirmed during the subsequent monitoring conducted in December 2007. This increasing methane concentration in fall is believed to be attributed to decreases in groundwater elevations during the fall. The gas pressure measured directly at these probes also indicated considerable variation ranging from a low of -8.7 inches at probe GP-IS to a high of 0.4 inches. As shown in Appendix D-1, the gas pressures at GP-ID have been stable near zero. Historical fluctuations in methane concentrations and pressures suggest that these two probes exhibit pronounced responses to the gas management system rebalancing efforts as well as fluctuations in groundwater elevations. As shown by Appendix D-1, the well field balancing efforts appear to be achieving compliance at these probes during the past year.

The observed pressure variations observed in the gas monitoring points during 2007 have ranged from a high of approximately +224 inches H_2O at probe GP-E in October to a low of -8.7 inches of H_2O at probe GP-IS during May 2007. The pressure in GP-E was nearly 200 inches H_2O for the last three months in 2007. As previously mentioned, many of the pressure variations do not appear to directly correlate to elevated methane levels or recent gas migration. Rather, the transient pressure readings are believed to be attributed to hydrostatic pressures due to fluctuations in groundwater elevations acting on landfill gas or soil gas trapped within the sand seam. A summary of the relevant gas probe observations are provided below:

- Methane concentrations above 50% of the LEL were observed during 2007 in probes (with number of sampling events) E-1 (11), GMP-13 (12), GMP-14 (7), GMP-15 (12), GMP-17 (9), GP-C (12), GP-D (7), GP-E (12), GP-H (8), GP-IS (1), GP-U (12), P-2C (9), P-6B (12), P-6C (1), and GMP-16C (2).

- Carbon dioxide values show wide variability, ranging from 0 (numerous probes) to 28.1% (E-1). Carbon dioxide concentrations in soil and groundwater are dependent on numerous biological and non-biological (abiotic) processes. The primary biological processes that produce carbon dioxide include methanogenesis in anaerobic environments such as landfills and respiration under oxic conditions commonly found in soils and groundwater. Once produced, carbon dioxide also will undergo additional non-biological reactions which may remove the carbon dioxide from the gaseous or aqueous phase. As a result, the concentration of carbon dioxide in soil gas or groundwater is dependent on numerous complex biological and non-biological processes. Thus, widespread variations in concentration are common. Additionally, exterior gas probes with low carbon dioxide levels and high methane levels may indicate that carbon dioxide has been removed from the gas due to contact with groundwater. Because carbon dioxide is much more soluble that methane (especially when under pressure) it may go into solution in the groundwater, thus reducing the concentration left in the gaseous phase. In some instances, elevated methane with low carbon dioxide levels may indicate gas that has been trapped with little or no recent gas movement from the landfill.

- Oxygen levels below atmospheric concentrations in the subsurface may occur due to O_2 diffusion from the atmosphere and therefore may be anticipated to vary or decrease with depth below ground surface. Oxygen levels may also be indicative of biogenic activity in the soil. Site values for oxygen range from near normal atmospheric concentrations (18 to 21%) to less than 1%.

The fact that probes GP-C, GP-H, and P-2C appear to indicate widely fluctuating methane levels suggests that the probes are being influenced by the perimeter groundwater collection system (i.e., Herst Associates Groundwater Extraction System) and/or water table fluctuations. It is not known whether these probes reflect new or relic gas migration episodes; however, because low carbon dioxide levels at each of these probes suggest that the gas is being altered by contact with groundwater, it is apparent that gas migration episode is old enough to have undergone changes in composition.

None of the four ambient air monitoring stations reported elevated levels of methane during any of the monthly monitoring events conducted during 2007.

Based on review of the gas probe monitoring data, STS believes that the landfill gas migration areas may be broadly grouped into one of the following three areas:

- The west side migration area extending from probes GMP-13 to GP-D (refer to Drawing 4);
- The south migration well TW-1 Area (refer to Figure 2);
- The south migration probe GPE area (refer to Figure 3); and
- The east migration area (presently limited to Probe GP-H refer to Drawing 5)

These migration areas have been defined based on historical gas monitoring results from the perimeter probe system. As previously mentioned, the gas detection along the east side of the site at GP-IS, GP-ID, GP-H appears to be relatively episodic in nature and occurs when the static pressures increase, suggesting that the gas management system is generally capable of controlling gas migration when it is properly balanced. However, dynamic conditions including barometric pressure changes, wind loading, groundwater level fluctuations, etc may make it difficult for the present system to achieve this balance. BFI is in the process of installing additional gas extraction wells along the northeast side of the landfill to help achieve capture of the landfill gas.

The occurrence of landfill gas outside the waste boundary at the site is controlled by the distribution of the W1/W2 unit and the degree of water saturation in this unit. The W1/W2 unit generally consists of a discontinuous, silty sand horizon that ranges from less than a foot to approximately 15 ft in thickness and is generally located between elevations 745 and 775 ft MSL. The W1/W2 unit is believed to have been deposited between advances of the glacial ice associated with the two uppermost Wadsworth diamictons (i.e., the W1 and W2 units). The W1/W2 layer may potentially intersect portions of the landfill sidewall or base grades. If present, these sand or silt deposits may have provided a pathway for gas migration.

Ground surface elevations in areas of the site where landfill gas has been detected in the W1/W2 unit (i.e., along the west side of the landfill and along the south side of the landfill) generally lie at or above 805 ft MSL. Therefore, the detected methane gas generally occurs at depths of greater than 35 ft bgs at the site. The W1/W2 layer is typically overlain by a relatively thick sequence of clayey till deposits along the south and west sides of the landfill. These till deposits minimize the potential for gas migration to shallower intervals. The extent of the gas migration within the W1/W2 sand unit is also limited by the saturated conditions which typically exist within the sand seam. The gas migration is generally restricted to areas where the gas pressures are greater than the groundwater hydrostatic pressures. Furthermore, the hydrostatic pressure helps to restrict the lateral extent of gas migration because gas migration through groundwater due to molecular diffusion is not nearly as efficient as gaseous diffusion through unsaturated sediments.

3.1.3 Responses to Gas Probe Exceedances

As required by 35 IAC 811.311, the landfill has implemented numerous corrective measures to address the migration of landfill gases. A landfill gas management system was installed during the late 1980s starting in the South Hill area. The gas management system was expanded as different phases of the landfill filling operations were completed. A landfill gas to electric energy generation plant has been constructed at the Mallard Lake Landfill. Operation of the electric energy generating station involves active recovery (i.e., the imposition of a vacuum on collector wells installed within the refuse) of landfill gas from the landfill. The landfill gas collection system currently consists of more than 230 collection wells. The installation of this collection system was accomplished over a period spanning several years. The last phase of collection wells and gas header piping was installed in October 1999, although, replacement wells and conveyance system improvements have been periodically undertaken. Landfill gas collected from the system is used to power three gas turbines, which generate electric energy used to augment the power grid. In addition, gas may also be burned at a large flare and a smaller utility flare.

On April 8, 2000, a Significant Permit Modification Application was submitted to the IEPA to address the corrective measures assessment conducted for the vinyl chloride at well G52S and other gas related impacts along the west and south sides of the landfill. The application was submitted following a public meeting, which was conducted on April 5, 2000. Because the groundwater impacts were attributed to landfill gas affects on the groundwater, the corrective measures focused on methods to alleviate excess gas pressures. Pursuant to the corrective measures assessment significant permit modification, the approved corrective action plan consisted of the completion of the final landfill cover system and the balancing and operation of the landfill gas management system. The plan required that the system operations be further refined and adjusted as necessary to maximize the influence at monitoring wells G52S, G131 and any GMZ monitoring probes (GMP-13, GMP-14 and GP-C).

Pursuant to permit modification No. 16 condition VIII.23(b) a significant permit modification evaluating the effectiveness of the corrective action in addressing vinyl chloride concentrations within the groundwater at wells G52S and G131 was submitted to IEPA on January 16, 2002 (Log 2002-018). This application proposed additional corrective measures to mitigate gas migration along the west side of the landfill. Application Log 2002-018 addressed the gas mitigation plan requirements of permit modification No. 14 Condition IX.13 (now Condition VIII.13 of modification No. 31). In addition, the vinyl chloride levels at the GMZ wells and detection monitoring wells (i.e. vinyl chloride was observed at G52S and G131 prior to 2007), also necessitated that additional corrective measures be implemented. The gas migration corrective action plan consisted of the installation of gas relief wells along the western perimeter fencing in the area of GMZ wells GMP-13, GMP-14 and GP-C.

The effectiveness of the gas recovery efforts along the west side of the landfill was assessed in July 2003. Based on this evaluation, Herst and Associates determined that additional dewatering effort was required. In February

2004, Herst and Associates submitted a significant permit modification application requesting approval to install additional gas venting wells (IEPA Application Log No. 2005-060). This application was approved on May 2, 2005 and vent wells PV6 through PV14 (refer to Drawing 4) were installed during early 2006. Reports detailing the gas mitigation corrective action efforts were submitted on an annual basis in July. The wells were used for combined groundwater and soil vapor extraction (SVE) to address the trapped gas along the west side of the landfill. Since methane levels at probes GMP-13, GMP-14 and GP-C were much lower in 2006, it was believed that the additional gas vent wells proposed by Application Log 2004-060 were helping to alleviate the concentrations of methane in these areas. However the concentrations subsequently appear to rebound in 2007. The most recent evaluation (Log No. 2007-313 submitted on July 13, 2007) was approved on March 18, 2008 (refer to Modification No. 31). This permit modification condition No. VIII.13 requires that the applicant comply with consent order docket RCRA 7003-5-08-001 requirements to monitor, investigate and control methane at and near the landfill.

The static gas pressure measurements at each of these probes GMP-13, GMP-14 and GMP-15 have decreased significantly from the levels in 2002 (i.e., prior to the installation of the Herst perimeter gas control system). Prior to the installation of the perimeter gas/groundwater recovery system, gas pressures in excess of 100 inches of H_2O were frequently observed at each of these probes. During the past three years, the gas pressures at GMP-13, GMP-14, GMP-15 and GMP-17 held relatively steady. STS believes that this data suggests that the head within the W1/W2 has been dewatered to beneath the upper confining surface. This depressurization is being conducted to promote the migration of the trapped gas to the collection points. It is hoped that this dewatering system has reduced the groundwater heads within the W1/W2 unit along the west property boundary sufficiently that methane can be extracted.

The methane concentrations at probes GMP-14 and GMP-17 were historically among the highest at the site however, both probes have exhibited significant decreases over the past several years (refer to Appendix D1). The decreases in methane levels at these probes is believed to result due to increased extraction efforts from either the west perimeter gas control system (i.e., Herst system) or from the extraction of gas from leachate collection line L509 which extends along the west side of the North Hill portion of the Landfill.

Gas wells W-16 and W-18 indicated brief periodic spikes in concentrations of methane during 2005. These methane concentration variations may indicate gas migration which occurred during periods of historically low water table elevations associated with a regional drought that occurred during that year. The screened interval of these wells appears to be interconnected with a shallow rock back-filled trench located up to 20 ft bgs. The trench extends along the eastern toe of the perimeter berm between the retention pond and well G131. The drought conditions in 2005 may have reduced groundwater infiltration from the shallow zone into the deeper W1/W2 layer allowing the migration of gas to wells W-16 and W-18.

Gas probes along the southern boundary of the landfill have also indicated relatively dynamic changes in gas concentrations. Probes P-6A and P-6B experienced pronounced increase in methane concentrations and gas pressure during early 2005, and a pronounced decrease in methane concentrations and gas pressure during the last half of 2005. Probe 6B repeated this trend in 2006 with a pronounced increase in methane concentrations and gas pressure during early 2006. The methane concentration and gas pressure decreased after the highs in the early part of the year, with a zero methane concentration coinciding with a negative pressure in September, followed by increasing methane and pressure through the rest of the year. Probe 6A did not repeat the high methane levels from early 2005, but remained at or near zero, with pressures also near zero, throughout 2006. Based on the fact that probe 6B appears to respond first and to a greater magnitude than probe 6A, it is believed that this shallower probe is located in closer proximity to the gas migration pathway. Probe E-1 which is located approximately 150 ft closer to the South Hill portion of the Landfill than Probes P-6A and P-6B has indicated generally high, but widely variable methane and carbon dioxide levels. The higher concentrations of CO_2 observed at probe E-1 may be more indicative of recent gas migration episodes. It is possible that this short duration migration occurs as a function of barometric pressure induced or seasonal groundwater level variation or some other outside influence. In 1994, a series of passive vent wells were installed by Terracon Inc. Two lines of passive gas venting wells were installed parallel to the landfill on the south side of the South Hill. The first line of passive vent wells consists of four wells (GVM-9 through GVM-12) that are located within 20 ft from the limit of waste between wells G149 and G138. The second line of wells is located on the north side of the berm that is located between Schick Road and the landfill all-season road. The second line consists of three passive vent wells (GVM-4 through GVM-6) that are located between E-1 and GP-A. The vent wells were equipped with a wind powered turbine to promote venting. Additionally, borings were completed west of each line, but sand seams were not encountered at those locations, thus no vent wells were installed. The series of passive venting wells were installed to limit the migration of landfill gas, however the turbine equipped vent wells do not appear to have been effective due to the fact that the intake intervals of these wells flood with groundwater due to the predominantly saturation nature of the W1/W2 layer.

Finally, probe GP-A which is located approximately 400 ft northeast of P6A-D (refer to Figure 2), continued to exhibit total methane concentrations in the 60% to 80% range during the first half of 2006. The probe began experiencing abrupt increases in methane levels and decreases in oxygen and balance gas which began in January 2003. The methane levels stabilized at approximately 80% in June 2003 but indicated wide variation in 2004 and 2005 before stabilizing again at approximately 70% in September 2005. For six months beginning with July 2006, the methane levels dropped to below 10%, but increased to 31% in December. The gas pressures at this probe have exhibited minimal fluctuation (have remained at approximately 0 inches throughout the past several years). The increase in methane levels in early 2003 appears to correspond to a short duration (i.e., 1 month) increase in the probe pressure of approximately 0.4 inches. STS believes that trapped gas migrated to probe GP-A during periods of lower water table elevation. Water table elevation appears to have recovered during 2007 and no gas was detected during each of the 12 monitoring rounds conducted last year. Therefore, based on current conditions, no additional corrective action appears to be required to address GP-A.

The geometric extent of the south gas migration area is likely to vary depending on groundwater elevations relative to the top of the sand seam. The 2005 Annual Report characterization of the gas concentrations indicate an abrupt decrease in the methane levels at probes P-6A and P-6B during the fall of 2005. This observation is also believed to be related to the 2005 drought.

A significant methane concentration decrease at probes P-6A and P-6B occurred late in 2005 after a prolonged drought. The methane concentration decrease appears to correspond to a pronounced decrease in the static pressure observed at the probes. In fact, negative static pressures observed at probe P-6B indicate that the probes were likely subject to a vacuum during the period extending from August to December 2005. Negative static pressures observed during late 2005 appears to correspond to a period of historically low groundwater level elevations that resulted from a prolonged regional drought. STS believes that the decrease in the groundwater elevation partially de-saturated the W1/W2 unit enabling the influence (vacuum) of the internal landfill gas collection system to extend beyond the limits of the landfill. Due to the proximity of the gas plant, a relatively strong vacuum (high negative pressures) are exerted along the southern perimeter of the landfill. Thus, the partial dewatering of the W1/W2 during 2005 may have re-established a pathway that had been saturated by groundwater to allow the previously trapped gas to migrate back toward the landfill gas collection system.

3.2 Analysis of Regional Glacial Geologic Conditions

A review of regional geologic data was conducted to establish a regional context for the site investigations. This review consisted of reviewing published and unpublished references from the ISGS, as well as the previous work by Bogner (1988) who performed an evaluation of the Mallard Lake Forest Preserve geology on behalf of the FPDDC. The results of these reviews are provided in subsequent sections.

3.2.1 Review of the Regional Geologic Data

STS obtained and reviewed regional glacial geologic figures obtained from the ISGS. An updated bedrock topography map of DuPage County was obtained from the ISGS website. The bedrock topographic map was compared to the surface topography in order to estimate the thickness of the glacial drift in the vicinity of the landfill and in the off-site investigation areas.

A regional geologic map and geologic cross-section prepared by the ISGS (Curry and Webb, 2007) was also reviewed. The geologic map indicated that the Mallard Lake Landfill is founded on the Wadsworth Formation diamicton which is stated to consist of silty clay and silty clay loam. Alluvial deposits consisting of the Henry Formation sand and gravel and the recent Cahokia alluvium sand and gravel deposits were mapped along the West Branch of the DuPage River just north of the Mallard Landfill. The geologic cross-section extended along the south side of the Mallard Lake Landfill and extended in an east-west direction roughly parallel to Schick Road.

As previously discussed in Section 1.4, Bogner (1988) related the stratigraphic units encountered at the landfill to the regional interpretations of the Pleistocene stratigraphy developed by the ISGS. The stratigraphic nomenclature is summarized on Figure 8.

The geologic cross section developed by the ISGS depicted a thickness of Wadsworth diamicton (till) typically ranging between 75 and 100 ft thick in the vicinity of the landfill. The bedrock below the South Hill area is shown on the ISGS cross-section at an elevation of approximately 650 to 660 ft MSL. The ISGS geologic cross-section did not attempt to subdivide the Wadsworth Till into individual members (i.e., W1, W2, W3, etc). Similarly, the cross sections do not attempt to identify inter-stratified granular units such as the silty sand deposits (referred to as the W1/W2 unit in this report).

3.2.2 Bogner (1988) Geologic Site Characterization

Bogner (1988) utilized geologic data from site borings conducted throughout the Mallard Lake and Mallard North landfill areas to develop 10 geologic cross sections. The locations of some of these cross-sections are depicted in Drawing 6. The geologic cross sections utilize the site boring logs to correlate various soil units to regionally recognized stratigraphic units previously identified by the ISGS, subdividing the Wadsworth into individual members on the basis of texture and engineering properties (Atterberg limits, water contents, blow counts, etc.). A granular silty sand unit was identified frequently occurring at elevations ranging between approximately 740 ft MSL and 775 ft MSL. These non-contiguous granular deposits were referred to as the W1/W2 interface unit. This nomenclature was subsequently adopted by several site investigators (i.e., RUST, STS, Herst, etc.).

Drawings 7 and 8 present the Bogner geologic interpretations in combination with the recent cone penetrometer test data for the west investigation area. Drawing 8 depicts a north-south trending cross-section which extends along the west side of the South Hill of the Landfill through Discovery Park and along the west side of the North Landfill area. The cross-section terminates at upgradient monitoring well G118 located on the north side of the Landfill. In general, the cross-section depicts the W1/ W2 unit occurring at an elevation generally ranging between approximate 740 ft MSL and 775 ft MSL. The granular units within W1/ W2 are shown as occurring as discontinuous lenticular units or thin seams. The W1/W2 sequence commonly includes inter-stratified silt sandy silt, sand and clayey silt deposits. The unit has been interpreted as representing a low energy (i.e., slow, quiet moving water) ice marginal alluvial or lacustrine depositional environment. The unit does not typically contain abundant organic matter, suggesting that it may have been deposited over a brief period. As previously mentioned, Curry and others (2007) and Bogner (1988) have described the Wadsworth Formation as consisting of a clayey silt to silty clay diamicton. The Wadsworth till tends to range from approximately 70 ft thick in the northern portion of the landfill site to approximately 110 ft thick near the southwest corner of the landfill.

Bogner indicates that the underlying Lemont Formation may contain numerous variable facies which are representative of lateral changes in the depositional environments. The Lemont Drift generally contains a basal outwash unit which often contains rubble from the underlying dolomitic bedrock. Hydraulically, the basal Lemont Drift tends to function as a combined aquifer unit with the underlying Silurian Dolomite bedrock.

Drawing 7 presents an east-west trending cross-section extending through the landfill to the western extent (Bartlett municipal boundary) of the west investigation area. As in the case of Drawing 7 the cross-section provided in Drawing 9 also indicates that the W1/W2 occurs within an elevation range of approximately 740 ft MSL to 775 ft MSL. Similarly, the sand units within the W1/W2 unit occur as discontinuous seams or lenticular units which are often separated by interlayer clay deposits. The apparent degree of discontinuity may be a function of the spacing of the geologic investigation CPT test locations. It is likely that the units would appear more contiguous if the test data was collected at closer spacings. This suggests that a small-scale fluvial (small creek or stream) or ice marginal lacustrine depositional environment is likely. Shown by the cross-section, an average of approximately 40 ft of Wadsworth clayey till overlays the W1/W2 granular unit. Similarly approximately 40 ft of Wadsworth appears to underlie the W1/W2 unit. In general, in the 1988 geologic cross sections and stratigraphic nomenclature developed utilizing landfill data fit the ISGS geologic sequence observed in the areas surrounding the landfill.

3.2.3 Regional Shallow Groundwater Flow Conditions

Very little regional data is available to assess regional groundwater flow conditions within the Wadsworth till unit. However, Charles Moore (1987) nested monitoring probes to develop cross sections which helped depict the vertical and horizontal groundwater flow through the glacial units. Figure 9 depicts the potentiometric surface map located along the west side of the South Hill of the landfill. The potentiometric cross-section indicates a horizontal gradient at the water table of approximately 10 ft of head lost per thousand feet of horizontal distance for gradient of approximately 0.01 ft/ft. Based on the cross-section shown in Figure 9, the horizontal groundwater flow direction appears to be towards the south. Relatively strong downward groundwater flow or recharge conditions are observed in nested wells completed along the west side of landfill. The vertical groundwater gradients are much steeper than the horizontal gradient. The upper portions of the potentiometric cross-section (i.e. above the W1/W2 layer) indicate that the downward vertical gradients approach 1.0 ft/ft. The vertical gradients below the W1/W2 layer do not appear as steep. The vertical gradients within the lower Wadsworth till appears to be approximately 10 ft head loss occurring over approximately 15 ft of till thickness or a downward vertical gradient of approximately 0.67 ft/ft. Similarly, the vertical gradients across the W1/W2 appear to range between 0.5 ft/ft and 0.75 ft/ft. The steep downward vertical gradients observed across the W1/W2 till unit suggest that unit collectively behaves as a significant barrier to vertical groundwater flow.

Figure 10 presents a potentiometric cross-section constructed along the south side of the landfill. The cross-section indicates similar conditions as were observed along the west side of the landfill (refer to Figure 9). A slight eastward component of shallow groundwater flow is apparent from the shallower probes completed near the water table. A slight eastward horizontal gradient of approximately 0.0014 ft/ft is shown by Figure 10. A different vertical to horizontal scale (i.e., vertical exaggeration) has been used on the south side of the landfill, however the vertical gradients also appear to be steeply downward with gradients ranging between 0.67 and 1 ft/ft. As in the case of Figure 9, the vertical gradients across the W1/W2 remain steeply downward, suggesting that the unit functions as a part of the confining layer for the underlying Lemont Drift and Silurian Dolomite Aquifer System. As shown by Drawing 1, portions of the landfill base grades have been excavated through the W1/W2 unit which typically occurs between 740 and 775 ft MSL. The excavated portions of the W1/W2 unit may influence groundwater elevations within the W1/W2 unit. For instance, construction dewatering creates a sink which may locally dewater portions of the W1/W2 unit.

3.3 Gas Migration Characterization Results

3.3.1 West investigation Area

A total of 120 CPT test locations were investigated within the area located west of the landfill. The investigated areas included the Forest Preserve District right of way, Hawk Hollow, Discovery Park, and the Village of Hanover Park parkway in the residential areas. The CPT test data was utilized to construct geologic cross sections through the investigation areas (refer to Figure 11). The geologic conditions observed in the west investigation area are depicted in cross sections A-A' (Figure 12) through G-G' (Figure 17). Geologic cross sections A-A' and B-B' were constructed in a predominantly east-west direction extending from the landfill toward the western extent of the investigation area. In the case of cross-section A-A', the investigation was extended to the approximate western extent of the Village of Hanover Park municipal boundary. As discussed in Section 2.7, the geologic cross sections were developed using the software program Rockworks 2006. The CPT test data and soil boring log information were entered into the program in order to construct a geologic model of the site. As shown by Figure 5, the CPT data was simplified by combining units to reflect cohesive or till units vs. granular units which comprise the W1/W2 unit. The program was then utilized to construct geologic cross sections through the areas of interest.

The Rockworks 2006 program allows different algorithms to construct the geologic cross sections. For instance the profiling mode can be utilized which allows data to be projected onto a profile line drawn between test locations or borings. Alternatively, the cross-section could be constructed utilizing the cross-section mode which may be configured to either rely on data physically falling on the line of the cross-section, or may be configured to rely on a model which weighs distance of other borings from the x-section line. Based on the apparent discontinuous nature of the W1/W2 and the observed rapid lateral facies changes, STS determined that the cross sections would be constructed utilizing specific data points falling on the cross-section. Therefore, no data was projected onto the line of the cross-section from adjoining points not falling on the line of the section.

Cross-section A-A' (Figure 12) suggests several very isolated sand seams located in the upper 40 ft of the Wadsworth formation. The sand and sandy silt deposits are shown as gray zones in the cross-section, whereas the clay intervals are shown in white. The sand seams occurring in the upper 40 ft are believed to have a lateral extent of no more than a few hundred feet (i.e., are not contiguous between borings). As in the case of the Bogner (1988) geologic cross sections, STS has correlated the granular units occurring between elevation 740 and 775 ft MSL with the W1/W2 unit described by Bogner at the landfill site. As discussed in Section 3.2.2, the W1/W2 unit (shown in gray) appears as numerous semi-continuous to discontinuous seams and/or lenses occurring at elevations 740 to 775 ft MSL. However, other site data including groundwater elevations and extent of landfill gas suggests that these sandy deposits may be continuous to a greater extent than is apparent from the cross sections. As previously stated, the CPT tests were typically conducted at spacings ranging approximately 300 ft on center. The deposits left by a small stream fluvial or a small scale lacustrine depositional environment, might be more continuous at a finer scale. Water level data and the extent of gas migration suggests that the W1/W2 silty sand deposits would appear more continuous at a finer investigative scale.

Geologic cross-section A-A' (Figure 12) suggests that the sand deposits are relatively contiguous between CPT test locations RW–3 and CP-61. Cross-section A-A' also indicates that the thickness of the W1/W2 increases significantly in the vicinity of RW-6. Directly to the east of RW-3, the W1/W2 unit granular deposits are shown as pinching out. This is consistent with the observation that no landfill gas was observed at RW-1 at the east end of the right of way. The presence of landfill gas (i.e., detectable levels of methane) is designated in the cross sections by an asterisk (*) next to the screen interval. Where no asterisk is present, no landfill gas was detected. Based on this data, it is apparent that the gas migration pathway extends from the southeast from the Discovery Park area towards Hawk Hollow and not directly from the landfill to the east.

Cross-section B-B' (Figure 13) is also constructed in an east-west orientation. The cross-section extends from probe GPT-1 located at the west side of the landfill through the southern portion of Discovery Park into the west along Victor Lane. The cross-section was terminated at CP-34 located in close proximity to the storm water detention pond located at the intersection of Camden Lane and Morton Road. Cross-section B-B' suggests slightly greater variation in the elevation of the W1/W2 sand units. However, the majority of the test locations still indicate the presence of granular deposits occurring at elevations ranging between 775 ft MSL and approximate 740 ft MSL. As indicated by the asterisk adjacent to the screen interval, landfill gas was detected throughout the majority of the eastern portion of cross-section B-B'. As shown by the asterisk adjacent to the screen interval shown in the cross-section the landfill gas is typically detected at depths of approximately 40 ft bgs. However, probe CP–33S encountered landfill gas at a minimum depth of approximately 28 ft. bgs.

Geologic cross-section C-C' (refer to Figure 14) extends in a north-south direction from the west side of the North Hill of the Mallard Lake Landfill (GMP-17 Area) to CP-63 located near the intersection of County Farm Road and Howe Lane. Cross sections C-C' indicates that the majority of the granular deposits are restricted to a channel area extending between CP-19 and CP-15. As shown by the cross-section probe CP-15 encountered gas (refer to asterisk adjacent to the screen interval) at a depth of approximately 50 ft bgs. Similarly, probe GMP-17 has also periodically indicated the presence of landfill gas. This probe was constructed with a long screen interval, so it is hard to determine the exact elevation of the gas impacted zone. However, granular deposits were encountered at GMP-17 at an elevation of approximately 750-755 ft MSL.

Geologic cross-section D-D' (Figure 15) extends in a southeast to northwest direction and passes through probes GPT-1 CP-1, CP-21, CP-14, CP-15, CP-20, RW-6, RW-8, RW-20, RW-12 and RW-13. The cross-section follows the approximate alignment of an alluvial channel which is believed to act as the primary migration pathway. Cross section D-D' reflects a longitudinal cross-section along the depositional trend. This longitudinal cross-section indicates a fairly continuous seam of granular deposits between elevations 765 and 745 ft MSL. As shown by the asterisks adjacent to the screen intervals, landfill gas was detected at the majority of the borings located between GPT-1 and RW-6, providing another indication of the apparent continuity of these deposits. Based on review of the screen interval elevations, sand seam thickness and the phreatic surface, it is apparent that some of the granular units did not contain gas because the screen interval and the adjoining sand seam are saturated with groundwater. The situation was observed at probe RW-6. STS believes that the granular unit present at this location may have acted as a gas migration pathway at some point in time. However, fluctuating groundwater elevations appear to have currently saturated this pathway. Thus, is likely that the migration pathway analysis must consider both the continuity of the sand deposits and the influence of the fluctuating water table.

Geologic cross-section E-E' (Figure 16) provides a transverse view of the alluvial channel deposits extending through the central portion of Discovery Park. The cross-section indicates that the granular deposits thin significantly in the vicinity of Discovery Park but thicken in the areas south of the Park and west of the Park. For instance, an approximately 5 ft thick granular zone is inferred to exist between borings CP-21 and CP-24. The existence of these granular deposits is based on granular unit thickness observed at CP-12 and CP-17. However, it is important to note that the granular deposits located south of Discovery Park occur at stratigraphically deeper elevations (approximately 750 to 755 ft MSL). These deeper granular deposits observed at CP-12, CP-22 and CP-17 tend to be saturated with groundwater and have not been observed to act as a gas migration pathway. As shown by cross-section E-E', the gas detections appear to be concentrated on the north side of the alluvial channel deposits (i.e., at CP-4 and CP-21).

Another interesting feature which is evident from cross-section E-E' is the clay block existing under the northern portion of Discovery Park. This clay block feature is relatively devoid of sand seams. The majority of the probes completed in the northern and central portions of Discovery Park have not encountered landfill gas. Probe CP-5S shown on cross-section E-E' indicates that the screen interval at this well nest has encountered landfill gas at a depth of approximately 20 ft. The landfill gas migration to probe CP-5S is believed to have occurred during a gas plant shutdown in late November due to vertical migration through one of the adjacent remedial action wells (i.e., PV-1 through PV-5). These passive vent wells are located at the top of the perimeter berm approximately 75 ft east of probe CP-5S. The passive vent wells were completed with long (approximately 60 ft) screened intake intervals. Thus, when the vent wells are not under vacuum, they may act as a conduit for vertical migration. The migration pathway to probe CP-5S, tends to have been corroborated by the rapid dissipation of the methane levels at probe CP-5 once the extraction was resumed at the passive vent wells. No further gas concentrations were detected at CP-5S during subsequent monitoring rounds while the perimeter extraction system was operating.

Cross-section F-F' (Figure 16) presents another cross-section located transverse or perpendicular to the depositional trend. The cross-section extends from probe GPT-3 toward the southwest to probe CP-50 and the retention ponds located adjacent to Morton Road and Camden Lane. The cross-section suggests several semi-continuous granular seams and lenses located throughout the cross-section at elevations ranging between approximately 768 ft MSL and 745 ft MSL. The granular deposits tend to be thickest and most permeable (based on the ability to retrieve groundwater samples) in the vicinity of probe RW-4. As shown by the asterisk adjacent to the screen intervals, gas was detected at probes RW-4, CP-20D and CP-28. Groundwater elevations were observed to abruptly increase towards the southwest at probes CP-50 and CP-42. The increase groundwater head is believed to be attributed to recharge occurring through the storm water detention ponds located in the area (refer to Section 3.6.1 for additional discussion).

Geologic cross-section G.-G' (Figure 17) extends through the western portion of the investigation area in an approximately northeast to southwest direction roughly transverse to the depositional trend described for the alluvial channel. The cross-section extends through CPT test locations are RW-13, RW-22, CP-47, CP-48, CP-53, and CP-58. the cross-section indicates semi- continuous to continuous granular deposits extending throughout the majority of the cross-section. The granular deposits tend to occur between elevations 770 ft MSL and 750 ft MSL. As shown by the asterisk adjacent to the screen intervals presented in cross-section G.-G', probes CP-47 and CP-48 were observed to have encountered combustible the gas. The gas at these locations appears to be migrating within sand deposits occurring at elevation of approximately 760 ft MSL to 768 ft MSL.

Figure 19 presents a geologic fence diagram extending through the west investigation area. The fence diagram is oriented in a manner where the line of sight is toward the northwest, looking towards Hawk Hollow from the landfill area. The fence diagram indicates that the granular deposits extend towards the northwest within a predictable elevation range. The transverse sections indicate that the deposits become sparser and less continuous towards the north and south ends of the section.

Figure 21 presents a structure contour map of the top of the W1/W2 layer within the western investigation area. The map depicts the surface of the W1/W2 granular layer as being very irregular. As previously stated, the top of unit elevations appear to range from approximately 740 to 775 ft MSL. No distinct slope or dip direction is apparent from inspection of the structure contours presented in Figure 16. The approximate edge of the gas impacted zone is presented in Figure 21 by the double line enclosed area. Similarly, probes which have encountered combustible gas are shown as red points. Probes without combustible gas concentrations are shown in blue. The combustible gas concentrations generally tend to correspond to areas where the surface of the W1/W2 layer occurs at stratigraphically higher elevations. Conversely, several probes located within the interior of the gas migration area (i.e., GP-17, RW-6, CP-19 and RW-16) did not encounter detectable concentrations of combustible gas. However, comparison of the probe as built screen elevation data and the sand seam elevations relative to the groundwater elevations indicate that the sand seam is fully saturated at each of these probes. Thus, the lack of combustible gas at locations GP-17, RW-6, CP-19 and RW-16 is attributed to lack of a vadose zone at these locations.

Figure 22 depicts the cumulative thickness of granular deposits within the W1/ W2 elevation range of 740 to 775 ft MSL. It is important to recognize that the map does not depict an isopach or actual thickness of a continuous granular sequence of deposits. This is the case because inter-dispersed clay and clayey silt layers are frequently observed within the W1/W2 sequence. The map is, however useful in depicting the overall sand thickness for purposes of estimating the transmissivity of the W1/W2 unit and in identifying potential areas where groundwater gas extraction might be feasible. This data will be further evaluated during the development of an offsite corrective action plan. As shown by Figure 22, the thickness of the granular deposits range from as much as 15 ft thick at probe RW-16 to being absent (i.e., 0 thickness) at numerous CPT test locations. Figure 22 also delineates the apparent alluvial or lacustrine depositional trend previously discussed. The alignment of this depositional trend extends from the area adjacent to the west side of the South Hill of the landfill in a northwesterly fashion through probes P2, CP-17, CP-14, CP-19, RW-4, RW-16, RW-6 and RW-7. The same depositional alignment may even extend to the south side gas migration areas observed in the vicinity of probes P-6B, GP-2 and GP-E. The depositional trend becomes less defined in the area west of the Village of Hanover Park water tower. As previously cautioned, the depositional alignment appears to be associated with the gas migration, but other factors clearly play a role in the migration. For instance, the groundwater elevation relative to the top of the sand seam is critical in providing a vadose zone for transport to occur through. Similarly, the hydraulic conductivity of the materials is also important in minimizing the resistance to gas migration.

3.3.2 The South Migration Area (Well TW-1 Migration Area)

A cone penetrometer test (CPT) test program was conducted to map the extent of the landfill gas and to obtain additional geologic data to be used to optimize the performance (i.e., location of extraction well(s)) that would be used to dewater depressurize the system. As is evident from the west side gas characterization and mitigation efforts, abrupt changes in the geology may greatly reduce the hydraulic influence and the effectiveness of the dewatering wells. As such, the CPT probes were advanced in the areas where landfill gas has been detected in order to characterize geological and hydrogeological conditions to help optimize the locations of the dewatering wells.

The CPT rig was used to characterize the geologic conditions and the location of trapped gas pockets in the south side investigation area. The CPT rig from Stratigraphics was mobilized to the site in June 2007 and conducted four CPT soundings and gas probe installations. The CPT soundings (GX-1, GX-2, GX-3 and GX-4) were completed in the area surrounding probes which had indicated historically elevated gas concentrations (i.e., E-1, P-6B, GP-2, and GP-A). CPT probes GX-1 and GX-2 were placed south and north of GP-2, respectively. Probes GX-3 and GX-4 were placed east and west of the E-1/G-132 area, respectively (refer to Figure 3).

As in the case of the west investigation area discussed in Section 3.3.1, The CPT holes were used to install 3/4-inch diameter Schedule 40 PVC monitoring probes which were used to monitor gas conditions and ground water levels. In addition, the 3/4-inch probes were used as observation points during the TW-1 radius of influence pump test. The gas probes were equipped with 5-foot long 0.010 inch slot well screens wrapped with a geotextile filter fabric. Bentonite packers were placed at 10-foot intervals on the riser pipe to provide an annular space seal. The probes were completed with a surface protective casing (refer to Figure 6) which were concreted into place. An STS geologist oversaw the CPT well installations performed by Stratigraphics. A LandTech GEM 500 or GA-90 was used to monitor the gas emissions during the course of the CPT soundings.

As a result of methane detections at probe GX-1, which is located along the southern property fence line, additional subsurface characterization was completed within the TW-1 south side investigation area. The additional characterization included the installation of a 6 inch diameter gas and groundwater extraction well completed within the W1/W2 granular unit as well as the completion of three addition CPT probes located offsite on the south side of Schick Road. The results of the geologic investigation in this area are discussed in the subsequent paragraphs.

Geologic cross-section Z-Z' (Drawing 9) presents an east-west trending geologic cross-section extending along the south side of the landfill. This cross-section links the well TW-1 investigation area with the investigations conducted in the vicinity of gas probe GP-E. Geologic cross-section Z-Z' extends through borings P-4, B-13, P-5, P-6. GP-2, GMV-5, E-2, G-103, E-3, P-11, P-8, GX-11, GX-9, GP-E, G-104A, GP-N, G139, GP-M, G-145 and R-105. The cross-section indicates that few if any granular seams are found at borings P-4 and B-13 completed along the southwest corner of the landfill. Several semi-continuous granular units are depicted as occurring between borings P-6 and GMV5.

Geologic cross-section H-H' (Figure 18) extends through probes GP-E, GX-9 and GX-12. Combustible gas has been detected at GP-E and GX-9 but does not appear to have migrated off-site to probes located along the southside of Schick Road. Geologic cross-section I-I' (refer to Figure 18) extends through the TW-1 gas migration area along an orientation which is perpendicular to cross-section Z-Z'. The geologic cross-section extends from collection well GVM-9 to offsite gas probe GX-6, located along the south side of Schick Road. The cross section depicts geologic information from monitoring well G-132, gas probe E-1, gas probe P-6, and CPT gas probe GX-1. The cross-section depicts a relatively thick granular unit in the vicinity of probes P6 and GX-1. However, based on the hydraulic pump tests conducted at extraction well TW-1 (located between P-6 and GX-1), the granular units are believed to be quite silty since the sustainable pump test well yield from the 6 inch diameter well was significantly less than one gallon per minute. Based on cross-section I-I', the W1/W2 granular unit appears to occur between elevations 750 ft MSL and 765 ft MSL. Based on the combustible gas measurements utilizing the GEM 500, no elevated levels of landfill gas were detected at the off-site locations located on the south side of Schick Road. The elevated gas concentrations appear to extend from probe E-1 to approximately gas probe GX1.

3.3.3 South Migration Area Probe GP-E. Area

As shown by geologic cross-section Z-Z', the granular deposits were also detected at probes GX-9 and GP-E. Both of these probes indicated two distinct granular units which were separated by five to 10 ft on intervening clay soils. A separate thicker sand seam is depicted as extending from wells G139 toward probe GP–E. However this sand seam is not believed to be contiguous based on gamma log data obtained from probe GP-N and based on the CPT data obtained from probe GX-8. The granular units shown at cross-section H-H' (Figure 18) occurred at elevations ranging between 740 and 774 ft MSL. As shown by the asterisked screen intervals shown in cross-section H-H', gas probes GX-9 and GP-E had encountered combustible gas. However, based on the lack of detectable combustible gas concentrations at nested probes P-8 and P-11, the two pockets of gas appear to be distinct from the gas detected at probes P-6, GP-2 and GP-A, rather than representing one larger Interconnected gas pocket.

As in the case of the west side gas migration area, the gas trapped in the sand seams along the south margin of the landfill are also influenced by fluctuating groundwater elevations. The fluctuating groundwater levels result in extreme variations in the pressure of the gases trapped at the top of the W1/W2 granular unit. As previously discussed, gas pressures in excess of 200 inches of water column have been detected at probes GP-E and GX-9.

3.3.4 East Side Investigation Area

Pursuant to concerns expressed by the Village of Bloomingdale, USEPA requested that an investigation be conducted to evaluate potential gas migration along the east side of the landfill. A total of eight CPT gas probes were installed along the east side of the landfill. Probes GPT-4, GPT-5 and GPT-6 were conducted in the area east of gas probes GP-IS and GP-H. As discussed in Section 3.1, both of these on-site gas monitoring probes have indicated periodic landfill gas concentration exceedances. Each of these probes was conducted at a distance of approximately 250 to 400 ft east of the landfill. The location of the CPT probes is shown on Drawing 5. Al three probes (GPT-4, GPT-5 and GPT-6) encountered relatively coarse granular deposits at shallower depths. These deposits were saturated at very shallow depths. These conditions did not provide for an unsaturated vadose zone migration route for landfill gas to migrate from the site. STS believes that it is apparent that the gas probes had penetrated into granular units which were hydraulically connected to the adjacent surface water bodies (i.e. Mallard Lake and the tributary to the West Branch of the DuPage River). Thus, the potential for gas migration along the east side of the landfill is limited by the presence of hydraulically connected surface water bodies.

USEPA also requested that several probes be installed at a greater distance from the landfill to evaluate potential migration towards residential areas. Five CPT test probes were installed within the Mallard Lake Forest Preserve to the northeast and east of the landfill (refer to Drawing 5 for probe locations). Probe ML-6, was located along the bike path south of Greenbrook School. The CPT probe was advanced approximately 54 ft. Open hole screening conducted after the CPT probe had been pulled from the hole did not indicate the presence of any combustible gases. A gas probe was installed at a depth of 48 to 53 ft. However, no evidence of landfill gas has been detected during the monitoring of this probe. Similarly, probes ML-1, ML-2, ML-3, and ML-7 were completed in granular soil zones without encountering any elevated combustible gas readings. Initially it was anticipated that two additional probes, ML-4 and ML-5, would be installed in the Mallard Lake Forest Preserve areas northeast of the landfill between the tributary of the west Branch of the DuPage River and the bike trail. However it was not possible for the CPT rig to access these locations due to the presence of corrugated metal piping below the bike trail and a narrow concrete pipe situated between lakes, below the access from the landfill. As such, probes GPT-4, GPT-5 and GPT-6 were completed as alternative monitoring locations.

STS believes that the potential for landfill gas migration toward the east is negligible since elevated groundwater table elevations exist in the area of the surface water bodies which are located in this area. Similarly, the fact that none of the eight monitoring probes completed east of the landfill encountered any elevated combustible gas concentrations indicates that no evidence of offsite gas migration exists in this direction.

3.4 Description of Soil Units

As discussed in Section 2.1, the majority of the investigations had been conducted utilizing cone penetrometer testing data to define the texture of the glacial soils and to define the gas migration pathways. Cone penetrometer results are based significantly on bearing capacity theory. Granular deposits tend to generate significant tip resistance whereas cohesive soils generate greater lateral or shear pressures. The tip resistance plotted as a function of the friction ratio (refer to Figure 5) are utilized to define a soil texture. As shown by Figure 5 granular soils including sands and gravels tend to fall in the upper left-hand corner of the diagram, whereas more plastically behaving soils tend to fall further towards the right and lower portions of the diagram.

As discussed in Section 2.1.5, soil borings were conducted at several locations where cone penetrometer tests were completed (adjacent right of way, borings B-1 (RW-1), B-3(RW-3) and B-4 (RW-4); at CP-20, CP-12D and RW-5I, CP-2I, CP-11I and CP-10I). The boring logs for each of these borings are presented in Appendix A4. The soil descriptions estimated from the cone penetrometer logs generally tend to closely agree with the descriptions presented in the boring logs. Where significant departures exist, it was observed that the CPT log tended to overestimate the relative percentage of the sand present in the soils. This likely occurs because the glacial tills possess a soil texture reflecting poorly sorted unstratified deposits consisting of sand and gravel in a predominantly silt and clay size particle matrix. Thus, the sand and gravel in the till likely give rise to increased tip resistances despite the predominant fine-grained soil matrix.

Table 4 , presents a summary of grain size analyses conducted on selected soil samples obtained from the W1/W2 stratigraphic unit. The grain size analyses indicate that the W1/W2 is characterized by pronounced variations in soil texture.

3.5 Gas Monitoring Results

3.5.1 Results of Field Instrumentation Probe Monitoring

As discussed in Section 2.1.7, the CPT gas probes were completed with an air tight sealed compression fitting surface completion. The gas pressure and composition was monitored on several occasions during the course of the field investigations. During several of the monitoring events the efforts to record gas concentrations and pressures were hampered by ice which had collected within the flush mount surface casing. The ice tended to freeze in the valves and in some instances cracked or broke the schedule 40 PVC riser pipe or fittings. In these instances, it was difficult if not impossible to obtain an airtight surface seal. These conditions often required that the ice be removed from the surface casing and in some instances new surface completions had to be installed at the probes.

As discussed in the December 6, 2007 work plan Section 2.1.6, the gas monitoring consisted of first recording the static pressure at the probe then monitoring the gas composition. During some of the rounds, the water level within the probe was recorded in conjunction with the gas pressure and composition monitoring. However, it became apparent that the field instrumentation utilized to monitor the gas composition (i.e., GEM 500 or GA-90) significantly disrupted the internal probe pressure such that potential existed for the water levels to be affected. As such, subsequent water level monitoring rounds were conducted separately, without pulling a sample vacuum from the probe. This minimized potential influences on the groundwater elevations.

The results of the gas probe monitoring are presented in Appendix D-3 and are summarized in Drawing 4 for the west side area and in Figures 3 and 4 for the south side investigation areas. The gas monitoring results indicate that the elevated gas concentrations are primarily restricted to the vicinity of the alluvial or lacustrine deposits defined in Figure 22. As shown by Table 5, the methane levels observed in the gas probes tend to be significantly elevated relative to the methane concentrations found in the landfill. Methane concentrations in excess of 90% are quite common in gas probes located outside the limits of waste. Conversely, the carbon dioxide levels generally tend to be less than 10% indicating that the CO_2 concentrations typically observed in the landfill have been reduced due to removal by other processes. Most significantly, STS believes that the CO_2 concentrations have been reduced due to contact with groundwater. Carbon dioxide solubility is directly proportional to the pressure. As shown by the historical monitoring results, gas pressures as high as 5 psi have been observed. These pressures are the direct result of fluctuating groundwater table influences on the trapped gas pockets. The carbon dioxide going into solution forms carbonic acid H_2CO_3 which in turn lowers the pH of the groundwater. These pH fluctuations are rapidly buffered by calcium carbonate presence in the aquifer matrix.

3.5.2 Results of Summa Canister Monitoring

Soil gas samples were collected in six-liter summa canisters from select CPT probes and monitoring points in November 2007, February 2008 and March 2008. The samples were analyzed for VOCs by Method TO-15 and major (gas) components utilizing Method 3C. The initial sampling event consisted of the collection of gas samples at six CPT locations (CP-1, CP-2, CP-4, RW-3, RW-4 and RW-5) along the western side of the landfill (refer to Drawing 10). In February 2008 an expanded sampling event was conducted and gas samples were collected at 17 additional locations (CP-14, CP-16, CP-18, CP-20D, CP-26, CP-29, CP-32, CP-38, CP-40, CP-47, CP-48, GP-E, GP-2C, GX-1, GX-9, P-6B and RW-8) on both the western and southern boundaries of the site. In addition to the soil gas samples, an ambient air sample collected during the February 2008 sampling event was utilized as a sample blank to test for potential field cross-contamination. A landfill gas sample was also collected on March 19, 2008 during the recent gas to energy plant shutdown. The landfill gas sample was obtained from a sample port located on the large flare piping inlet. The gas sample was collected to provide a basis of comparison to the summa canister results collected from the W1/W2 formation outside of the landfill.

The gas sample analysis reports for the November 2007 and February 2008 sampling events are included in Appendix D-4. Table 6 summarizes the detected constituents for the Method TO-15 analyses as well as the major gas composition for the soil gas samples. Review of the November 2007 results indicates that the concentrations of non-halogenated VOC constituents were low with the total non-halogenated VOC concentrations of the samples ranging from 8.5 to 17 PPBv. For all but CP-1, the concentration of the halogenated VOC concentrations was even lower. Excluding CP-1, the sum of halogenated VOC samples ranged from non-detect to 9.6 PPBv during the November 2007 monitoring round. The predominant VOC in a majority of these samples was 1,2-dichlorotetrafluoroethane.

During the November 2007 monitoring event, the only sample that had an appreciable concentration of halogenated VOCs was CP-1. The total halogenated VOC concentration for CP-1 was 250 PPBv of which 1,2-dichlorotetrafluoroethane accounted for 240 PPBv of the total. With respect to vinyl chloride, only CP-1 had a detectable concentration. Vinyl chloride was detected at 8.5 PPBv in CP-1, while the remaining five samples did not have detectable concentrations above the 0.5 PPBv reporting limit.

As indicated by the results presented in Table 6, 1,2-dichlorotetrafluoroethane (R-114) was the predominant halogenated compound detected in a majority of the November 2007 samples. Historically, 1,2-dichlorotetrafluoroethane (R-114) was a commonly used refrigerant. As such, refrigeration equipment disposed in the landfill prior to the white goods ban would be the probable source of this constituent. At atmospheric temperatures and pressures 1,2-dichlorotetrafluoroethane would exist as a gas. If present in the landfill, 1,2-dichlorotetrafluoroethane would be expected to be present in and migrate with landfill gas. Thus, its occurrence with landfill gas (methane) is not of a surprise since it is essentially an inert gas which is also relatively resistant to microbial degradation. Given these properties, STS believes that R-114 provides a good tag element or indicator constituent for discerning landfill gas contamination from other potential biogenic methane sources (i.e., swamp gas etc.).

The results of the Method 3C compositional analysis of the gas samples is presented at the bottom of Table 6. The November 2007 results show the presence of methane in all six samples. The lowest concentrations were observed at samples RW-3 (20%) and RW-4 (16%) located within the right of way. The presence of methane in a majority of the samples is expected since the investigation/sampling plan intentionally targeted locations where methane had previously been documented. The presence of methane also supports the conclusion that the samples were collected without significant atmospheric dilution.

The results for the February 2008 samples are presented in Table 6. The Method 3C compositional analysis results for the samples is presented at the bottom of the table. These results show the presence of methane in all but sample P2C. The presence of methane in the majority of samples was anticipated since the investigation targeted locations where methane had previously been documented. Similarly, the February 2008 monitoring results indicate laboratory methane concentrations that coincide closely to the methane concentrations reported based on the field monitoring (refer to Appendix D-2). The method 3C analyses also indicate that nitrogen comprises the majority of the balance gas during both sample rounds for the majority of the gas probes.

Review of the February 2008 results indicates that the concentration of non-halogenated VOC is low in a majority of the samples. Specifically, the results for the non-halogenated compounds ranged from non-detect to 21 PPBv in 13 of the 17 samples (plus two duplicates). The total non-halogenated concentrations of the remaining samples collected in February 2008 (i.e., CP-20D, CP-26, CP-29, CP-47, CP-48 and CP-49) are also low, ranging from 37 to 205 PPBv. With respect to the non-halogenated constituents reported in these samples, the dominant constituent was not consistent from sample to sample. Thus, it would appear unlikely that the occurrence of these constituents is related to the presence of landfill gas (methane).

The non-halogenated results for CP-26 are probably the most unusual when compared to the remainder of the March 2008 samples because of the presence of a greater number of non-halogenated constituents as well as the presence of toluene at a relatively high concentration (150 PPBv) relative to the rest of the samples and/or constituents detected. What is also unusual about the gas sample for CP-26 (specifically the toluene results) is that a water sample collected from the probe just a couple weeks later (refer to Table 7) did not contain a majority of the compounds detected in the gas/summa canister samples. Specifically, the groundwater did not contain the aromatics (benzene, ethyl benzene, toluene and xylenes) reported in the summa canister results. Thus, the summa canister results for CP-26 appear to be potentially questionable, and any significance probably should not be placed on the data until the results have been confirmed by additional monitoring results.

Review of the halogenated VOC summa canister data indicates that concentrations for the February 2008 samples ranges from non-detect to 651 PPBv. The most common halogenated constituent detected in the samples was 1,2-dichlorotetrafluoroethane (R-114). This refrigerant was reported in 9 of the 17 samples at concentrations that ranged from non-detect to 410 PPBv. In general, the detection of 1,2-dichlorotetrafluoroethane was greatest in the samples that contained the highest methane concentrations. As indicated previously, the presence of R114 refrigerant along with the landfill gas (methane) is expected since this refrigerant would exist primarily in gaseous form within the landfill environment.

As show by the results, 1,2-dichlorotetrafluoroethane was the only halogenated compound of significant concentration detected in a majority of the samples. However, vinyl chloride and tetrachloroethene were also detected in a few samples. Vinyl chloride was detected at CP-14 and P-6B and tetrachloroethylene was detected at probe GX-1. The tetrachloroethylene concentration exhibited at GX-1 was the highest VOC constituent concentration observed at any of the probes including CP-26 which was dominated predominately by non-halogenated VOCs. The unusual results for CP-26 were discussed previously. Review of the halogenated VOC results for sample GX-1 suggest that they are potentially anomalous when compared to the rest of the data. The dominant compound noted in the GX-1 sample was tetrachloroethylene (410 PPBv). Other than a few samples with trace concentrations, tetrachloroethylene generally was not observed in the majority of the other summa canister samples. While investigating potential sources and/or possible means for cross-contamination, it was discovered that the transducer had been utilized at a project site where tetrachloroethylene had been released.

Although the transducer was decontaminated, the detection of low PPBv detection of tetrachloroethylene may indicate that the transducer and cable had absorbed sufficient tetrachloroethylene to cross-contaminate the sample. To confirm this hypothesis, the transducer that originally was placed in GX-1 was sealed inside a 10-foot piece of 4" PVC. A summa canister sample of the air in contact with the probe was collected and analyzed after being isolated in the PVC with the transducer overnight. The results of this experiment are included in Table 6 and labeled as GX-1 Probe Blank". These results indicate that the blank sample exhibited a tetrachloroethene concentration of 2000 PPBv. Thus, the transducer blank sample results show a similar suite of chlorinated VOCs and the concentrations appear to be approximately five times greater than the concentration observed at probe GX-1. Figure 26 presents the normalized chlorinated VOC concentrations (normalized by dividing a specific chlorinated VOC constituent by the sum of the chlorinated constituents) for the transducer blank and the GX-1 groundwater. As shown by Figure 26, the transducer blank and the GX-1 groundwater indicate very close agreement in the concentrations of chlorinated compounds indicating that the transducer is the likely source of the probe GX-1 cross contamination. Thus, it is clear that the transducer acted as the source of cross contamination of the summa canister's obtained from this probe.

The summa canister results for CP-14 and P-6B were the only two of the 17 samples collected in February 2008 to contain reportable concentrations of vinyl chloride. CP-14 is located west of the landfill, while P-6B is located the southern perimeter of the landfill site. As such, the presence or spatial extent of vinyl chloride appears to be very isolated and confined only to a minimal portion of the methane impacted area.

The vinyl chloride concentrations at each of these probes appear to be associated with the landfill gas as indicated by the fact that the landfill gas sample collected on March 19 indicated a vinyl chloride concentration of 340 PPBv. As such, the presence or spatial extent of vinyl chloride appears to be very isolated and confined only to a minimal portion of the methane impacted area.

In conclusion, the summa canister results for November 2007 and February 2008 confirmed the presence of methane as indicated by the field equipment. With one exception, the non-halogenated VOC concentrations of the samples were generally low and averaged less than 20 PPBv. The exception was location CP-26 which indicated the presence of toluene. However, the presence of toluene was not confirmed in the groundwater sample from CP-26. Thus, the summa canister results for CP-26 appear to be somewhat anomalous.

The total halogenated VOC concentration in a majority (15 of 23) of the samples was less than 10 PPBv. With 20 of the 23 samples less than 50 PPBv. The most frequently detected halogenated compound (which was also generally present at the highest concentration) was 1,2-dichlorotetrafluoroethane (a common refrigerant). It was detected in 11 of the 23 summa canister samples. The detected concentrations of 1,2-dichlorotetrafluoroethane ranged from 2.3 to 410 PPBv. Where detected, the refrigerant concentrations were only slightly above trace levels with four isolated exceptions (CP-1, CP-14, GP-E and P-6B). CP-1 and CP-14 are located just to the west of the landfill, while GP-E and P-6B are located within the property boundary on the southern side of the site. The presence of elevated 1,2-dichlorotetrafluoroethane concentrations appeared to be associated with vinyl chloride.

Vinyl chloride was reported in only three of the 23 samples analyzed. As discussed in the preceding paragraph, the presence of vinyl chloride appeared to correlate with the higher concentrations of 1,2-dichlorotetrafluoroethane. Vinyl chloride was also detected in the landfill gas sample obtained from the utility flare inlet. In any case, based on the summa canister results the spatial extent of vinyl chloride (and 1,2-dichlorotetrafluoroethane) is very isolated and confined only to a minimal portion of W1/W2 unit area where methane impacts have been observed.

3.5.3 Residential Screening and Combustible Gas Detector Installation

The USEPA initiated the air monitoring of homes with field instrumentation in the area of the detected gas migration (west of the landfill and Discovery Park) on Saturday November 17, 2007. On November 19, 2007, the USEPA (and/or their subcontractor), the Hanover Park Fire Department and STS began joint monitoring of indoor air quality. The field instrumentation utilized was capable of detecting methane, carbon monoxide, hydrogen sulfide, oxygen and volatile organic compounds (VOCs). The initial monitoring was conducted by going door to door basis. It became very apparent that this was an inefficient way to conduct the residential monitoring since very few residents were found to be a home. Therefore, in early December a proactive outreach plan was initiated by BFI which focused on the area to the west of the landfill and Discovery Park. BFI contracted Reputation Partners to contact area residents regarding the combustible gas screening. The program consisted of phone calls to approximately 400 residences. If contact was successful, the objectives of the monitoring program were explained to the resident and a request (via an appointment) was made to obtain access to the premises to conduct the air quality screening. Residences that were unable to be contacted via telephone were visited by STS. If no one was home at the time of that visit, a door hanger was left at the home which provided project information and a contact for the resident to schedule the air quality screening.

The initial screenings conducted in November and those conducted as part of the proactive active program resulted in the screening nearly 250 homes. To date, the home screening program has not detected the presence of methane attributable to the landfill. In addition to the screening, the installation of a combustible gas detector was offered to residents beginning on November 26, 2007. Installation of the combustible gas detectors focused on the area of the home where potential ignitions sources were present (i.e., furnace and hot water heater). As of March 28, 2008, a total of 215 combustible gas detectors have been installed at screened residences. To date, only two combustible gas detector alarms have sounded and resulted in a call to the local fire department. Inspection of one of the residences by the fire department and STS identified a leak in the furnace (natural gas) supply line. No apparent source was identified for the alarm at 1811 Whitney Lane on April 2, 2008. The gas detector was replaced and has not sounded since being replaced.

Appendix F1 includes a drawing of the locations in the primary investigation area west of the landfill where home screening and combustible gas detectors have been installed. A list of all the homes receiving air quality screening and the installation of a combustible gas detector is enclosed in Appendix F2

3.5.4 Shallow Soil Gas Survey

At the request of the USEPA, shallow soil gas surveys were targeted for the gas migration investigation area west of the landfill and Discovery Park. A total of 8 surveys (addresses) were completed in December. Each survey consisted of three or four shallow soil borings conducted around the perimeter of the home. None of the shallow soil gas surveys completed identified the presence of landfill gas or related constituents (refer to Appendix D-5).

The shallow soil surveys consisted of a ¾" diameter probe which was advanced approximately 2 ½ ft bgs, the probe was retracted and tubing inserted into the top of the hole. The hole was sealed off at the surface and a GEM 500 used to draw and analyze the soil gas from the probe. In general, the shallow soil gas surveys encountered impermeable clay soils and were hindered because of frozen soil conditions as well as an inability to visually find utility markings because of heavy snowfalls. Additionally, many of the probes encountered a very shallow water table which has resulted in the aspiration of water into the field gas meter instrumentation. As such, the shallow soil gas surveys were postponed until more conducive weather conditions exist. Appendix F1 includes a drawing with the completed and pending shallow soil gas survey locations. A tabulated list of the homes where permission has been granted to conduct the soil gas survey ("slam bar testing) is included in the residential screening results table enclosed in Appendix F2

3.6 Groundwater Monitoring Results

3.6.1 Groundwater Level Monitoring

Due to difficulties accessing the flush mount monitoring probes during periods of heavy snow in February and March, it was difficult to obtain groundwater level monitoring data. Additional rounds of monitoring will be conducted once the snow and the ice have thawed. The groundwater elevation data is presented in Appendix C. As discussed in Section 2.3.1, monitoring of the groundwater elevations has been complicated by trapped gas which is pressurized within the same granular units. USEPA has requested that the monitoring probes not be allowed to openly vent to the atmosphere. As such, it is not possible to obtain groundwater level measurements which are equilibrated to atmospheric conditions. As such, the data has been presented in Figure 23 as a plot of the total pressures within the W1/W2 granular unit. The total pressure was calculated as the sum of the gas pressure, hydrostatic pressure from the measure groundwater elevations and any barometric pressure corrections necessary to normalize the data with respect to barometric pressure changes occurring during the period that the water levels were recorded. As such Figure 23 should not be deemed to reflect a simple water table or potentiometric surface map.

Figure 23 clearly indicates a narrow channel which is partially de-watered along the north flank of the channel depicted in the cumulative sand thickness map presented in Figure 22. As is evident from comparison of Figure 22 and Figure 23, the alignment of the thickest sand deposits and the trough in the equipotential contours follow a very similar alignment. STS interprets this as being indicative of the presence of coarse grained deposits which create a hydraulic conductivity contrast which has allowed the dewatering influence of the west side corrective action system to preferentially propagate along this alignment. As shown by Figure 23, the trough extends from roughly probe CP-1 in the southern portion of Discovery Park to CP-21, CP-14, CP-19, RW-4, RW-16, RW-7, RW-8, RW-19, RW-18 and RW-22. The alignment of the axis of this channel appears to be extremely narrow in the vicinity of the landfill suggesting that the area of hydraulic contact to the landfill may be less than 100 ft wide or so.

The other notable feature apparent from Figure 23 is that the equipotential head contours tend to increase abruptly in the vicinity of the storm water detention ponds located in the vicinity of Camden Lane and Morton Road. This suggests that the surface water bodies act as localized groundwater recharge points for the water contained within the W1/W2 granular unit.

The equipotential contours have been utilized in combination with the structure contour map of the top of the W1/W2 layer to construct a map of the thickness of the vadose zone (refer to Figure 24). This map is of critical interest in developing a remedial strategy for the collection of gas from offsite areas. Where possible it is anticipated that gas recovery wells will be located in gas containing areas where the vadose zone is thickest and greatest hydraulic conductivity exists. This should help minimize the need for groundwater dewatering and should facilitate recovery of the gas. As shown in Figure 24, the vadose zone appears to be thickest along the southern margin of Discovery Park and in the County Farm Road area within the central portion of the U.S. Homes subdivision.

Because the cone penetrometer study was only recently completed it has not been possible to obtain seasonally distributed groundwater elevation monitoring data from the CPT probes. As such, the ability to assess the range of groundwater elevation fluctuations within the W1/W2 granular unit is limited. STS has reviewed historical groundwater level monitoring data from the detection monitoring wells and GMZ probes located along the west side of andfill. STS has concentrated this effort at reviewing the water level data for wells and probes completed within the W1/W2 granular layer. As shown by Figure 26, the groundwater elevations along the west side of the landfill are quite erratic and reflect the influence of seasonal variations in the water table as well as the influence of the groundwater extraction system operating along the west perimeter of the landfill.

As shown by Figure 26, monitoring well G131 has exhibited approximately 13.5 ft of groundwater level fluctuation, varying from a maximum of 776.83 ft MSL during the second quarter of 2002, to a minimum of 763.05 ft MSL during the first quarter of 2008. Similarly, detection monitoring well G52S has exhibited approximately 11 ft of groundwater elevation fluctuation, with levels ranging from a maximum of 770.22 ft MSL during the second quarter of 2002 to a minimum of 759.11 ft MSL during the fourth quarter of 2005. As shown in Figure 26, groundwater elevations have generally decreased since mid 2002. The landfill west perimeter passive vent remedial action system was installed in early 2003. However, minimal groundwater level fluctuation was observed following the installation of PV-1 through PV-5. In 2006, Herst Associates received approval to install supplemental groundwater dewatering and gas extraction wells. Groundwater dewatering wells PV-6 through PV-14 were installed during mid-2006. These wells appear to have resulted in a more pronounced decrease in groundwater elevations. A decrease in groundwater elevation corresponds closely with the decrease in vinyl chloride concentrations observed at monitoring wells G52S and G131. The vinyl chloride concentrations appear to be closely associated with gas pressures. Reduction of the groundwater elevation appears to have alleviated the vinyl chloride concentrations by reducing the trapped gas pressures. As previously discussed in Section 3.3, the solubility of some gases, such as carbon dioxide, is directly proportional to pressure. Based on this discussion it is anticipated that groundwater dewatering will continue to both provide a vadose zone for gas extraction and to mitigate the vinyl chloride concentrations.

3.6.2 Groundwater Quality Monitoring Results

Groundwater samples were collected from eight CPT probes on November 28 and 29, 2007. The monitoring event included the collection of samples at CP-2, CP-3, CP-5, CP-9, CP-11, CP-12, RW-4 and RW-5. The samples were analyzed for VOCs by method SW846-8260. The laboratory report for these groundwater samples is included in Appendix E-1.

Review of the data package has not identified any issues which would preclude the use of the analytical data. However, it should be noted that because of shipping error the samples collected during the November monitoring round arrived at the laboratory without the presence of ice in the cooler. The samples were shipped by STS for a Saturday morning delivery, but were not actually delivered to the laboratory until Monday. As a result, the ice had melted and the samples arrived with an elevated temperature (14.6°C). Prior to analyzing the samples, the temperature issue was discussed with the USEPA. Based on this discussion, it was agreed to analyze the samples rather than delay the results in order to recollect the samples.

A second sampling event was conducted at 19 probe/well locations between March 6 and 24, 2008. This monitoring event included the collection of samples at several of the sample points (CP-2, CP-12, RW-4 and RW-5) included within the November 2007 event, but also included numerous points located farther west from the landfill which had not yet been installed at the time the first monitoring event was conducted. Beside the four monitoring points that were re-sampled, the March monitoring event included the collection of samples at CP-4, CP-12D, CP-15, CP-19, CP-26, CP-28, CP-30, CP-33S, CP-35, CP-38, CP-47, CP-55, RW-6, RW-8 and RW-26. As discussed in Section 2.3.2, the monitored locations were selected in mutual agreement with the USEPA and Weston Solutions based on the potential metric data presented in Figure 23. The groundwater monitoring plan was described in STS' letter to USEPA dated February 29, 2008.

The groundwater samples collected during the March 2008 monitoring round were analyzed for VOCs by method SW846-8260. The laboratory report for these groundwater samples is included in Appendix E-2. Review of the laboratory data package for the March sampling event did not indicate any reasons to preclude the use of the analytical data.

Table 7 presents the constituent concentrations reported above the reporting limits for both the November 2007 and March 2008 sampling events. Also included in the table are the laboratory reporting limits, Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and the landfill's Applicable Groundwater Quality Standards (AGQSs) for the till unit from the groundwater permit issued by the IEPA (refer to condition VII.12).

There were a total of 27 groundwater samples analyzed during the two monitoring events excluding the blanks, duplicates and matrix spike samples. Review of Table 7 indicates that the detected constituents list is limited to seven compounds (i.e., acetone, carbon disulfide, chloromethane, methylene chloride, methyl ethyl ketone, toluene and tetrahydrofuran). Tetrahydrofuran was analyzed and subsequently detected at monitoring point CP-12D. Probe CP-12D was initially installed with the hollow stem auger drilling rig on January 14 and 15, 2008. However, the well's protector casing was offset by frost heave. When the flush-mount was opened to inspect/sample the well, it was apparent that the flush-mount casing has shifted horizontally and did not allow access to the well. The drilling subcontractor, Subsurface Exploration Inc., was contacted to correct the problem. A member of the drill crew returned to the site to correct the flush-mount issue. However, without STS's knowledge or permission, an extension to the PVC casing was made during the flush-mount repair process. When the well was opened for sample collection on March 12, 2008, it was evident from visual inspection that PVC primer and cement had been utilized for the repair. Discussions with the driller confirmed the use of PVC primer and cement. Therefore, as soon as possible after the discovery the upper section of the PVC casing was removed from the well and replaced. A material safety data sheet (MSDS) for these materials was obtained from the drillers. A copy of the MSDSs is included in Appendix E-3. The PVC primer and cement that was utilized primarily contains four major volatile components including acetone, methyl ethyl ketone (2-butanone), tetrahydrofuran and cyclohexanone.

On March 24, 2008, well CP-12D was sampled. The sample collected from the well was analyzed for the standard list of VOCs as well as tetrahydrofuran. As a result, the three predominant components in the PVC primer and cement were included in the VOC analysis. The analytical results for CP-12D indicated the presence of all three of the PVC primer and cement components. As shown in Table 7, acetone was detected at 24 ug/L, methyl ethyl ketone at 15.5 mg/L and tetrahydrofuran at 33.9 mg/L. No other VOC constituents were reported in the sample.

Although the PVC primer and cement contaminated portion of the well was removed, it is apparent from the analytical results that the groundwater sample results of the three VOCs has been impacted by the use of PVC primer and/or cement. Based on experience with PVC materials, it is not uncommon for organic contaminants to persist or be present in subsequent samples even after the removal of the glued portion of the pipe. Basically, with the exception of the PVC cement/primer introduced contaminants, the CP-12D VOC results are consistent with the remaining groundwater results and show a general absence of VOCs. Thus, it does not appear necessary to replace well CP-12D at this time given the following data:

- The general absence of other VOC constituents other than those identified as being associated with PVC glues;
- The lack of VOC detections in groundwater samples collected from on-site monitoring wells and GMZ probes; and
- The lack of any discernible VOC plume from the onsite monitoring well and offsite probe data.

Carbon disulfide was detected at the reporting limit 1 ug/L in the November 2007 monitoring event at probe RW-4, but not subsequently detected in the March 2008 event. Carbon disulfide is known to be produced naturally at low concentrations particularly in organic sediments and is also utilized as a fumigant in agricultural processes. The detection of carbon disulfide at the reporting limit at a single probe, which was subsequently not confirmed, is likely the results of a laboratory false-positive or attributable to natural variability in background water quality. In any case, the carbon disulfide data does not warrant additional investigation based on the frequency of detection and the magnitude of detected concentrations.

Methylene chloride was detected at a concentration of 4.3 ug/L in the November 2007 monitoring event at probe CP-12. However, subsequent monitoring in March 2008 did not confirm the detection. Furthermore, methylene chloride was not detected at any other monitoring points nor was it detected at a significant frequency in the summa canister air samples collected from the investigation area (refer to Table 6). The concentration of methylene chloride reported at CP-12 is below both the groundwater permit AGQS and drinking water MCL limit of 5 ug/L. With respect to potential sources, methylene chloride is one of several commonly used solvents within analytical laboratories. Although a review lab report did not indicate the presence of methylene chloride within the associated laboratory blanks, the detection of low concentrations of methylene chloride in analytical samples is not uncommon. Due to the fact that methylene chloride is utilized in numerous laboratory extraction processes, it is a common laboratory artifact. Thus, the detection of methylene chloride at CP-12 is believed to be a laboratory false-positive given the magnitude of the sample concentration, the fact the results were not confirmed by the subsequent March 2008 monitoring round and the fact that the constituent is used as a solvent in the laboratory.

Toluene was not detected in any of the eight samples collected in November 2007. However, toluene was detected in four of the 19 samples collected in March 2008. The detected concentrations ranged from 1.1 ug/L at CP-2 to 17 ug/L at RW-5. All of the detected concentrations are well below the drinking water MCL of 1 mg/L (1,000 ug/L) and only the result detected at RW-5 was above the groundwater permit AGQS value of 5 ug/L (refer to Mallard Lake Permit Condition VII.12 for AGQS). Review of the analytical data for RW-5 indicates that toluene was not detected above the reporting limit of 1 ug/L in the initial sample collected in November 2007. Similarly, the results at CP-2 were non-detect in November 2007, but were slightly above the reporting limit (1.1 ug/L) during the March 2008 sampling event. The detection of toluene at two sample points in March 2008 when the previous monitoring had not indicated the presence of toluene may suggest that the results are likely false-positives or may indicate a source of field or laboratory cross-contamination.

Toluene is a common solvent and component of fuels. As such, toluene is a common component of groundwater impacts associated with leaking underground storage tanks and fuel spills. Additionally, because of the widespread use of fuels, detections of toluene could also result from the cross-contamination of samples or sampling equipment. However, the limited detection of toluene (4 of 19 samples) and the magnitude of the detected concentrations does not suggest widespread cross-contamination of the samples or sampling equipment is likely. Thus, it is possible that the low concentrations essentially at the reporting limit are false-positives. With respect to RW-5, the results appear to be an anomaly. They are inconsistent with the summa canister results (Table 6) which indicated a trace of toluene (1.3 PPBv) in the air sample collected in November, but an absence of the constituent in the November groundwater sample. In any case, the concentrations and the spatial distribution across the investigation area (refer to Table 7 and Drawing 4) do not indicate a relationship between samples that would suggest a groundwater impact attributable to the landfill or any other source. Pursuant to the work plan requirements, and additional round of groundwater quality monitoring will be conducted at these wells and will provide additional data.

Chloromethane was detected at only three of the 27 samples. The detected concentrations ranged from 1.0 ug/L to 2.6 ug/L compared to a reporting limit of 1.0 ug/L. Chloromethane was reported in only one of the summa canisters (RW-8 at 5.9 PPBv). Low concentrations of chloromethane can be produced naturally, but the magnitude of the chloromethane detections in groundwater in the investigation area appears to be more likely false-positives. In any case, well RW-8 will undergo an additional round of VOC monitoring.

Methyl ethyl ketone (MEK) was detected in only two of the 27 samples. As previously discussed, MEK is a component of PVC cement. As such, the concentration observed at CP-12D has been attributed to the inadvertent use of the PVC cement at this monitoring point. The only other detection of MEK occurred at CP-4 during the March 6 monitoring event. The observed concentration of 6.8 ug/L is only slightly above the 5 ug/L reporting limit and well below the groundwater permit AGQS value of 20 ug/L. The absence of wide-spread MEK detections and the extremely low MEK concentration detected at CP-4 suggest that there is no reason to support the existence of MEK groundwater contamination. In any event, probe CP-4 will undergo another round on the VOC monitoring in a couple months.

Of the constituents detected in groundwater, acetone was detected at the greatest frequency (in approximately 33% of the sample results). The detected concentrations of acetone ranged from14 ug/L to 46 ug/L. It is worth noting that the highest concentration (46 ug/L) occurred at shallow nested probe CP-12 in November 2007. However, results for acetone at CP-12 in March 2008 were below the reporting limit of 10 ug/L. Conversely, the November 2007 result was reported below the reporting limit at RW-5, while the March 2008 results indicated a concentration of 14 ug/L. Thus, there is little if any consistency in the acetone concentration observations. Acetone is also a common laboratory solvent and as such is frequently reported as a contaminant (i.e., false-positive). As a result, many laboratories often utilize higher reporting limits for acetone to avoid potentially reporting false-positives. Although acetone was reported at low concentrations (generally less than 10 PPBv) in a number of the summa canister air samples, there does not appear to be a relationship between the observed concentrations in air and groundwater or even to the presence/absence of landfill gas.

Finally, none of the 27 groundwater samples collected from the off-site locations indicated any reportable concentrations of vinyl chloride. As previously discussed in Section 3.1, vinyl chloride was detected at on site monitoring wells G-52S and G-131 but the concentrations of this constituent have been abated over the past year due to corrective action efforts conducted on the west side of landfill. The off-site monitoring results tend to confirm earlier hypotheses that the vinyl chloride was limited to localized zones around the perimeter of the landfill where the gas had flowed through or come in contact with groundwater.

In summary, the groundwater results for the samples collected in November 2007 and March 2008 indicated a very limited number of VOC detections. In general, where more than one round of samples have been collected, there tends to be little or no consistency in the monitoring results suggesting that the detections might be associated with possible field or laboratory cross contamination of the samples. The magnitude of the VOC detections have been very minor (i.e., very low ug/L) with the most frequent detection and highest concentrations observed for acetone. Acetone was observed in only about a third of the samples and of the constituents reported is one of the most frequent laboratory introduced artifacts (i.e., false positives). In any case, review of the detected constituents and concentrations, individually or in combination, reveals no spatial distribution or trends in the data. It is also important to note that the chlorinated VOCs are essentially absent in the groundwater sample results. Finally, although landfill gas was observed either at or in the vicinity of a majority of the sample points, the results indicate that there has been little or no VOC impact on groundwater.

4.0 Conclusions

The preceding sections detail the extent of the landfill gas impacts identified in the area surrounding the Mallard Lake Landfill. The on-site investigations were initiated in November 2007 and were recently completed in March 2008. Investigations have identified two primary areas of landfill gas migration. The largest area of migration exists on the west side of the landfill extending from Discovery Park, approximately 2/3 of a mile through portions of the US home subdivision toward Hawk Hollow to the northwest the landfill. The gas is typically migrating through a silt, silty sand and sand deposits collectively referred to as the W1/W2 unit. The W1/W2 unit is present at a depth of approximately 30 to 50 ft bgs. This unit has been referred to as the W1/W2 sand unit. Gas has not been detected in any of the nearly 250 homes that have been monitored in the migration area. Similarly, none of the shallow gas probes (less than 15 ft deep) constructed in residential areas have detected the presence of methane. Methane detection devices have been installed at residences requesting such services within the affected areas.

A separate migration area has been delineated along the south side of the landfill. The south migration area has been subdivided into two separate investigation areas. The area encompassed by gas probes E-1, P-6B, GP-2, GP-A and GX-1 has been referred to as the TW-1 area, referring to the name of the extraction well which has been installed in this area to facilitate dewatering and methane extraction (refer to Figure 3). A second migration area has been identified near the southeast corner of the landfill. This zone is delineated by probes GP-E and GX-9. This area is referred to as the GP-E area (refer to Figure 4). Both of these two southern migration areas appear to reflect relatively small trapped gas pockets which are present in the predominately saturated portions of the W1/W2 sand unit.

All three of the gas migration areas are characterized by relatively elevated methane concentrations. Both the field instrumentation (i.e., GEM 500 detector) and the laboratory analyses (USEPA method 3C) indicate that the methane concentrations sometimes exceed 80%. The majority of the remaining gas is comprised of nitrogen. However, carbon dioxide has also been identified at probes which are in closer contact to the migration pathway from the landfill or have been more recently affected by gas migration from the landfill. Landfill gas concentrations within the landfill are typically much closer to balanced, with methane comprising approximately 55% and carbon dioxide 45% of the gas concentration by volume. The methane concentrations become enriched when the carbon dioxide is removed due to contact with groundwater. This occurs when the gas migrates into unsaturated sand which later becomes flooded when the groundwater elevations increase. The ability of carbon dioxide to solubilize and go into solution is directly proportional to pressure (Drever, 1982). The carbon dioxide which goes into solution forms carbonic acid (a weak acid) which slightly lowers the pH of the groundwater. Evidence of this process is apparent from the historical gas static pressures which have been observed to exceed 200 inches of water column and from the historical groundwater quality evaluations and assessment monitoring reports which have been issued for monitoring wells G-52S and G-131.

Summa canister monitoring conducted at more than 20 locations throughout the west and south migration areas indicate that the total VOC concentrations at the monitoring probes are low, comprising less than 1/1000 of 1% of the total gas concentrations by volume. The most frequently detected organic compound was 1, 2-dichlorotetrafluroethane or (R114). This constituent was detected in 13 of the 25 probes (including duplicates) that were sampled at off-site locations. As discussed in the preceding report, R114 is a common refrigerant constituents which has a high vapor pressure and is relatively inert so it does not readily react or attenuate. Relatively low concentrations of ketone constituents including acetone and 2- butanone or MEK were also detected as was the aromatic constituent toluene. Detections of vinyl chloride were limited to 3 of the 23 samples locations (CP-1, CP-14 and P-6B). The vinyl chloride concentrations range from the non-detect (i.e., less than 0.5 PPBv) at the majority of the locations to a high of 230 PPBv at probe CP-14. The landfill gas sample collected from the flare was characterized by higher VOC concentrations and by a wider variety of constituents (refer to Table 6).

The texture of the W1/W2 granular deposits and the degree of saturation of these deposits appear to exert a primary influence on the gas migration pathways. The W1/W2 interval ranges from being nonexistent to silty sand deposits (USCS classification SM) or poorly-graded fine to coarse sand deposits (USCS classification SP). An elongated cone of depression in the groundwater surface has been observed extending from the southern portion of Discovery Park toward the northwest to Hawk Hollow nature preserve. The cone of depression appears to be originating from the groundwater dewatering efforts which are occurring along the west side of the landfill (refer to Figure 23). This cone of depression appears to have elongated along the granular deposits which comprise the W1/W2 unit. Figure 24 depicts the unsaturated zone or vadose zone thickness. The map indicates a thin zone of unsaturated granular deposits extending along the apparent channel alignment toward the northwest. Where present, this unsaturated zone may provide a means for vacuum extraction of the gas. However, due to seasonal fluctuations in groundwater elevations it is likely that some groundwater dewatering will be needed.

5.0 Gas Migration Management Approach

The physical transport of gases in the subsurface is complex because it can be mediated by several processes, including (whole gas) pressure gradients, species-specific concentration gradients which drive diffusive transport, and ebullition (bubble transport through liquids). At the soil-atmosphere interface, emissions of gases into the atmosphere are further complicated by two additional processes: plant-mediated transport and wind-driven convection.

With respect to the potential lateral migration of landfill methane, the two most important physical transport mechanisms are convective and diffusive processes which can both simultaneously influence gas transport. A very important consideration with respect to diffusive transport of methane is that the diffusion coefficient for transport of methane through air is approximately four orders of magnitude less than the diffusion coefficient for transport of methane through water - thus, continuously-saturated sediments in the subsurface can provide an effective barrier to gas migration. The converse is also true in that seasonally unsaturated sediments can provide pathways for gas migration to occur.

Because the methane detected within the inter-till unit (referred to as W1/W2 unit) is generally within a variably saturated unit which is often below the seasonal high water table, it is much more difficult to mitigate the gas migration which has occurred, than typical migration within the unsaturated or vadose zone. It is believed that much of the gas detected in the W1/W2 unit is likely to have migrated during periods shortly after landfill construction when the water table was lowered by excavation dewatering or during drought periods. As such, it is believed that the gas became trapped in the granular deposits adjacent to the landfill by geologic conditions (i.e., non-contiguous geologic units) or hydrostatic pressure created by groundwater elevations.

Where the seasonally low groundwater potentiometric surface occurs above the top of the W1/W2 confining unit, the potential for significant gas migration is limited. Based on the preceding discussion, STS believes that the existing gas management system and the geology and naturally occurring hydrostatic pressures in the W1/W2 sand seam combine to limit the migration of landfill gas away from the landfill along the south side. However, the same geologic and hydrogeologic conditions also limit the ability to vent or collect the gas from the sand seam. This results in areas of trapped gas that may expand and shrink depending on the confining pressures exerted by the piezometric surface elevation fluctuations. The methane and pressure measurements at probes P-6A and P-6B suggest that drought conditions in 2005 reduced these confining pressures caused by the piezometric surface and enabled the gas bubble to enlarge and to migrate back toward the landfill where the gas management system was creating a vacuum. The same drought event appears to have lowered the piezometric surface along the southeast side of the landfill such that a limited volume of gas was able to escape the landfill and collect in the vicinity of GP-E. This gas was later pressurized significantly when the groundwater elevation rebounded from the drought.

The groundwater elevations within the granular unit along west side of the landfill may have historically been influenced by a number of factors. First, the landfill development likely resulted in partial dewatering of the sand seam as some of the cells were constructed below the elevation of the sand seam. Second, the residential developments to the west of the landfill are likely to have disrupted the groundwater recharge conditions which existed prior to the development. For instance, surface drainage is likely to have been increased due to the paved areas, storm sewers and roof drains. As noted by Moore (1993), these features result in less water reaching the W1/W2 granular unit and possibly resulted in a decrease in the groundwater elevations to the west of the landfill. These factors may have contributed to the landfill gas migration by providing an unsaturated pathway for the migration to occur through.

STS is in the process of developing a comprehensive corrective action design which addresses not only the off-site gas migration but also identifies ways to eliminate the pathway to stop future gas migration. These corrective action strategies will be discussed in the final corrective action plan report.

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Figures

Table 1

Summary of Offsite Gas Migration Investigation

Mallard Lake Landfill
Hanover Park, Illinois

Well Name	Description			Site Coordinates		IL St. Plane E		Ground Surface	Top of Flush Mount Casing	Top of PVC (for wells >2" dia.)	Mid Valve Elevation	Top of Valve Stem	Screen Interval				Sounding Terminal Depth	Sounding Terminal Elevation	Notes
	Type of Borehole	Well Construction	Contractor	Northing	Easting	Northing	Easting						Top	Bottom	Top	Bottom			
				(ft)	(ft)	(ft)	(ft)	(ft MSL)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft bgs)	(ft bgs)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	
CP-01	CPT	3/4" PVC well	Stratigraphics	2052.5	-46.8	1,927,148.1	1,035,035.0	807.62	807.62		807.36		42.1	47.1	765.5	760.5	52.75	755.37	
CP-01S	Geoprobe	1" PVC well	Terra Trace	2058.1	-47.5	1,927,153.7	1,035,034.3	807.72	807.89		807.46		4.0	10.0	803.7	797.7	12.0	795.72	
CP-02	CPT	3/4" PVC well	Stratigraphics	2137.4	-147.1	1,927,233.5	1,034,935.1	807.54	807.54		807.34		41.6	50.9	765.9	756.6	54.75	752.79	
CP-02I	Geoprobe	1" PVC well	Terra Trace	2141.5	-144.2	1,927,237.6	1,034,938.0	807.76	807.92		807.53		30.5	35.5	777.3	772.3	36.0	771.76	
CP-02S	Geoprobe	1" PVC well	Terra Trace	2135.3	-140.9	1,927,231.4	1,034,941.3	807.78	807.78		807.54		4.0	10.0	803.8	797.8	12.0	795.78	
CP-03	CPT	3/4" PVC well	Stratigraphics	2274.6	-23.5	1,927,370.1	1,035,059.3	814.24	814.24		814		46.1	56.0	768.1	758.2	59.00	755.24	
CP-03S	Geoprobe	1" PVC well	Terra Trace	2270.1	-28.7	1,927,365.7	1,035,054.1	813.79	813.79		813.59		4.0	10.0	809.8	803.8	12.0	801.79	
CP-04	CPT	3/4" PVC well	Stratigraphics	2251.2	-241.7	1,927,347.7	1,034,841.0	809.14	809.14		808.93		39.4	49.4	769.7	759.7	59.00	750.14	
CP-04S	Geoprobe	1" PVC well	Terra Trace	2247.17	-236.2	1,927,343.7	1,034,846.5	809.3	809.33		808.89		4.0	10.0	805.3	799.3	12.0	797.30	
CP-05	CPT	3/4" PVC well	Stratigraphics	2494.5	-7.2	1,927,590.0	1,035,076.6	818.32	818.32		817.97		50.3	60.3	768.0	758.0	62.00	756.32	
CP-05S	Geoprobe	1" PVC well	Terra Trace	2499	-6.8	1,927,594.5	1,035,077.0	818.4	818.38		817.93		25.0	30.0	793.4	788.4			
CP-06	CPT	3/4" PVC well	Stratigraphics	2507.7	-133.1	1,927,603.7	1,034,950.8	816.38	816.38		816.02		45.0	55.0	771.4	761.4	61.0	755.38	
CP-07	CPT	3/4" PVC w/ Prepack Screen	Fugro	2456.6	-296.4	1,927,553.4	1,034,787.2	812.57	812.57		812.24		43.5	58.5	769.1	754.1	64.68	747.89	
CP-08	CPT	3/4" PVC w/ Prepack Screen	Fugro	2627.4	-136.0	1,927,723.4	1,034,948.4	818.85	818.85		818.41		44.0	54.0	774.9	764.9	58.84	760.01	
CP-09	CPT	3/4" PVC well	Stratigraphics	2616.8	-572.9	1,927,714.8	1,034,511.5	812.77	812.77		812.48		50.4	55.4	762.4	757.4	59.5	753.27	
CP-10	CPT	3/4" PVC well	Stratigraphics	2366.2	-156.7	1,927,462.3	1,034,926.5	812.31	812.48		812.22		40.0	50.0	772.3	762.3	70.32	741.99	
CP-10I	Geoprobe	1" PVC well	Terra Trace	2399.2	-104.9	1,927,495.1	1,034,978.5	814.31	814.38		814.05		32.0	37.0	782.3	777.3	37.0	777.31	
CP-10S	Geoprobe Casing Driven (No Core)	1" PVC well	Terra Trace	2401.8	-107.9	1,927,497.7	1,034,975.5	814.21	814.27		813.69		20.0	25.0	794.2	789.2	25.0	789.21	
CP-11	CPT	3/4" PVC well	Stratigraphics	2337.3	-446.5	1,927,434.8	1,034,636.6	811.59	811.59		811.34		45.1	50.1	766.5	761.5	58.75	752.84	
CP-11S	Geoprobe	1" PVC well	Terra Trace	2342	-447.9	1,927,439.5	1,034,635.2	811.72	811.82		811.45		35.0	40.0	776.7	771.7	40.0	771.72	
CP-12	CPT	3/4" PVC well	Stratigraphics	1881.7	-29.8	1,926,977.3	1,035,051.2	805.02	805.02		804.81		40.0	45.0	765.0	760.0	70.25	734.77	
CP-12D	4" O.D. Wash Bore Rotary	2" PVC well	SEI	1887.08	-29.1	1,926,982.6	1,035,051.9	805.24	805.24	805	N/A		54.0	64.0	751.2	741.2	65.0	740.24	
CP-13	CPT	3/4" PVC w/ Prepack Screen	Fugro	2616.8	-359.7	1,927,713.9	1,034,724.7	816.51	816.51		816.06		47.0	57.0	769.5	759.5	67.7	748.81	
CP-14	CPT	3/4" PVC w/ Prepack Screen	Fugro	2211.2	-739.9	1,927,310.0	1,034,342.6	810.73	810.73		810.4		44.0	54.0	766.7	756.7	53.4	757.33	
CP-15	CPT	3/4" PVC w/ Prepack Screen	Fugro	2207.1	-1000.0	1,927,307.1	1,034,082.5	809.67	809.67		809.15		46.0	56.0	763.7	753.7	63.04	746.63	
CP-16	CPT	3/4" PVC w/ Prepack Screen	Fugro	1975.8	-783.8	1,927,074.8	1,034,297.6	810.5	810.5		810.09		40.0	50.0	770.5	760.5	61.4	749.10	
CP-17	CPT	3/4" PVC w/ Prepack Screen	Fugro	1992.9	-570.2	1,927,090.9	1,034,511.3	808.85	808.85		808.36		49.5	54.5	759.4	754.4	55.17	753.68	
CP-18	CPT	3/4" PVC w/ Prepack Screen	Fugro	2466.8	-643.5	1,927,565.1	1,034,440.2	811.48	811.46		810.94		40.0	50.0	771.5	761.5	63.89	747.59	
CP-19	CPT	3/4" PVC w/ Prepack Screen	Fugro	2468.4	-994.4	1,927,568.3	1,034,089.3	810.83	810.83		810.14		52.5	62.5	758.3	748.3	62.32	748.51	
CP-20	CPT	3/4" PVC w/ Prepack Screen	Fugro	2336.58	-1552.5	1,927,439.1	1,033,530.6	804.22	804.28		803.91		28.5	38.6	775.7	765.6	38.51	765.71	
CP-20D	4" O.D. Wash Bore Rotary	3/4" PVC w/ Prepack Screen	SEI	2337.33	-1547.9	1,927,439.8	1,033,535.2	804.34	804.44		803.91		42.0	47.0	762.3	757.3	50.5	753.84	
CP21	CPT	3/4" PVC w/ Prepack Screen	Fugro	2063.5	-315.5	1,927,160.4	1,034,766.3	807.42	807.42		807.07		35.0	45.0	772.4	762.4	44.35	763.07	
CP-22	CPT	3/4" PVC w/ Prepack Screen	Fugro	1733.1	-207.9	1,926,829.5	1,034,872.4	803.98	803.98		803.45		43.0	53.0	761.0	751.0	58.84	745.14	
CP-23	CPT	3/4" PVC w/ Prepack Screen	Fugro	2332.3	-1761.7	1,927,435.7	1,033,321.4	801.99	801.99		801.64		36.2	46.5	765.8	755.5	54.65	747.34	
CP-24	CPT	3/4" PVC w/ Prepack Screen	Fugro	1694.4	-675.8	1,926,792.9	1,034,404.4	806.19	806.18		805.68		40.5	50.5	765.7	755.7	53.86	752.33	
CP-25	CPT	3/4" PVC w/ Prepack Screen	Fugro	1697.26	-368.2	1,926,794.4	1,034,712.0	805.39	805.41		805.02		46.7	51.7	758.7	753.7	54.32	751.07	
CP-26	4" O.D. Wash Bore Rotary	2" PVC well	SEI	1769.9	-1306.2	1,926,871.3	1,033,774.3	803.4	803.47	803.03	N/A		34.0	44.0	769.4	759.4	54.84	748.56	
CP-27	CPT	3/4" PVC w/ Prepack Screen	Fugro	2040.4	-1402.7	1,927,142.2	1,033,679.0	805.1	805.1		804.56		35.0	40.0	770.1	765.1	51.5	753.60	
CP-28	CPT	3/4" PVC w/ Prepack Screen	Fugro	2015.33	-1578.7	1,927,117.9	1,033,502.9	802.9	802.89		802.41		34.0	44.0	768.9	758.9	46.97	755.93	
CP-29	CPT	3/4" PVC w/ Prepack Screen	Fugro	2016	-1888.6	1,927,120.0	1,033,193.0	799.73	799.58		799.19		32.0	42.0	767.7	757.7	49.99	749.74	
CP-30	CPT	3/4" PVC w/ Prepack Screen	Fugro	2148	-1986.6	1,927,252.5	1,033,095.6	800.18	800.18		799.59	799.95	45.0	50.0	755.2	750.2	53.99	746.19	
CP-30S	Casing Driven Only (No Cone)	3/4" PVC w/ Prepack Screen	Fugro	2145.18	-1987.3	1,927,249.6	1,033,094.9	799.89	799.94		799.49		31.0	41.0	768.9	758.9	41.0	758.89	No Sounding Completed. Refer to CP-30
CP-31	CPT	3/4" PVC w/ Prepack Screen	Fugro	1706.7	-1916.6	1,926,810.8	1,033,163.6	798.73	798.73		798.03		30.0	45.0	768.7	753.7	49.99	748.74	
CP-32	CPT	3/4" PVC w/ Prepack Screen	Fugro	1705.9	-1552.0	1,926,808.4	1,033,528.2	801.39	801.39		801		32.0	42.0	769.4	759.4	49.99	751.40	
CP-33	CPT	3/4" PVC w/ Prepack Screen	Fugro	1825.4	-1983.3	1,926,929.8	1,033,097.5	799.18	799.16		798.78		43.0	48.0	756.2	751.2	50.97	748.21	
CP-33S	Casing Driven Only (No Cone)	3/4" PVC w/ Prepack Screen	Fugro	1823.5	-1984.2	1,926,928.0	1,033,096.6	799.11	799.17		798.69		26.0	36.0	773.1	763.1	36.0	763.11	No Sounding Completed. Refer to CP-33
CP-34	CPT	3/4" PVC w/ Prepack Screen	Fugro	1703	-2370.1	1,926,809.2	1,032,710.1	796.27	796.27		795.93		49.0	54.0	747.3	742.3	60.22	736.05	
CP-35	CPT	3/4" PVC w/ Prepack Screen	Fugro	1861.84	-2322.4	1,926,967.8	1,032,758.5	797.57	797.6		797.22	797.46	45.0	60.0	752.6	737.6	62.32	735.25	
CP-35S	Casing Driven Only (No Cone)	3/4" PVC w/ Prepack Screen	Fugro	1859.25	-2322.2	1,926,965.2	1,032,758.7	797.58	797.59		797.24		28.0	38.0	769.6	759.6	38.0	759.58	No Sounding Completed. Refer to CP-35
CP-36	CPT	3/4" PVC w/ Prepack Screen	Fugro	2118.7	-2322.2	1,927,224.7	1,032,759.9	799.09	799.09		798.71	798.88	37.5	47.5	761.6	751.6	53.79	745.30	
CP-37	CPT	3/4" PVC w/ Prepack Screen	Fugro	2328.9	-2176.3	1,927,434.2	1,032,906.8	798.73	798.73		798.22	798.56	34.0	44.0	764.7	754.7	55.5	743.23	
CP-38	CPT	3/4" PVC w/ Prepack Screen	Fugro	2508	-2286.1	1,927,613.8	1,032,797.8	799.17	799.17		798.72	798.96	35.0	45.0	764.2	754.2	48.09	751.08	
CP-39	CPT	3/4" PVC w/ Prepack Screen	Fugro	1571.42	-1055.2	1,926,671.6	1,034,024.4	802.31	802.31		801.96		30.0	45.0	772.3	757.3	53.79	748.52	
CP-40	CPT	3/4" PVC w/ Prepack Screen	Fugro	2450.7	-2523.2	1,927,557.6	1,032,560.4	802.94	803.12		802.68		36.0	46.0	766.9	756.9	52.02	750.92	
CP-41	CPT	3/4" PVC w/ Prepack Screen	Fugro	1405.37	-1459.8	1,926,507.4	1,033,619.1	798.34	798.4		798.05		27.0	37.0	771.3	761.3	54.91	743.43	
CP-42D	CPT	3/4" PVC w/ Prepack Screen	Fugro	1405.98	-2058.2	1,926,510.8	1,033,020.7	795.14	795.25		794.81		35.0	50.0	760.1	745.1	54.84	740.30	Refer to Fugro log CP-42
CP-42S	CPT	3/4" PVC w/ Prepack Screen	Fugro	1403.17	-2057.0	1,926,508.0	1,033,021.8	795.23	795.21		794.71		25.0	35.0	770.2	760.2	71.9	723.33	Refer to Fugro log CP-42D
CP-43	CPT	3/4" PVC w/ Prepack Screen	Fugro	2259.5	-2634.3	1,927,366.9	1,032,448.5	803.45	803.58		803.11		32.0	47.0	771.5	756.5	58.97	744.48	
CP-44	CPT	3/4" PVC w/ Prepack Screen	Fugro	1938.87	-2509.6	1,927,045.7	1,032,571.7	797.66	797.66		797.26		41.0	46.0	756.7	751.7	51.96	745.70	
CP-45	CPT	3/4" PVC w/ Prepack Screen	Fugro	2662	-2699.1	1,927,769.7	1,032,385.5	802.4	802.5		802.18		36.3	46.3	766.1	756.1	45.85	756.55	
CP-46	CPT	3/4" PVC w/ Prepack Screen	Fugro	2439.11	-2834.0	1,927,547.4	1,032,249.6	805.84	805.89		805.5		32.0	42.0	773.8	763.8	55.96	749.88	
CP-47	CPT	3/4" PVC w/ Prepack Screen	Fugro	2665.77	-2884.6	1,927,774.3	1,032,200.0	804.76	804.94		804.5		38.6	53.6	766.2	751.2	53.4	751.36	
CP-48	CPT	3/4" PVC w/ Prepack Screen	Fugro	2451.95	-3165.8	1,927,561.8	1,031,917.8	805	805.02		804.62		36.2	41.2	768.8	763.8	54.91	750.09	
CP-49	CPT	3/4" PVC w/ Prepack Screen	Fugro	2461.95	-3355.1	1,927,562.6	1,031,728.5	803.9	803.95		803.62		35.0	45.0	768.9	758.9	54.38	749.52	
CP-50	CPT	3/4" PVC w/ Prepack Screen	Fugro	1366.68	-2257.1	1,926,472.4	1,032,821.6	793.34	793.36		793.05		34.7	44.7	758.6	748.6	59.96	733.38	
CP-51	CPT	3/4" PVC w/ Prepack Screen	Fugro	2023.32	-2881.3	1,927,131.9	1,032,200.4	802.29	802.34		801.89		26.4	36.4	775.9	765.9	36.34	765.95	
CP-52	CPT	3/4" PVC w/ Prepack Screen	Fugro	2132.25	-3008.7	1,927,241.4	1,032,073.5	801.19	801.21		800.75		33.0	43.0	768.2	758.2	49.92	751.27	
CP-53	CPT	3/4" PVC w/ Prepack Screen	Fugro	2186.66	-3176.6	1,927,296.5	1,031,905.8	802.32	802.36		802.01		36.0	46.0	766.3	756.3	50.91	751.41	
CP-54	CPT	3/4" PVC w/ Prepack Screen	Fugro	2675.8	-3277.5	1,927,786.1	1,031,807.2	805.53	805.63		805.23		37.1	42.1	768.4	763.4	41.79	763.74	
CP-55	CPT	3/4" PVC w/ Prepack Screen	Fugro	2669.22	-3510.2	1,927,780.6	1,031,574.4	805.28	805.42		805.05		33.8	43.8	771.5	761.5	43.76	761.52	
CP-56	CPT	3/4" PVC w/ Prepack Screen	Fugro	2674.45	-3818.1	1,927,787.2	1,031,266.5	807.21	807.38		807.02		46.0	56.0	761.2	751.2	57.93	749.28	
CP-57	CPT	3/4" PVC w/ Prepack Screen	Fugro	2127.69	-3497.2	1,927,239.0	1,031,585.0	803.69	803.72		803.34		35.0	45.0	768.7	758.7	53.99	749.70	
CP-58	CPT	3/4" PVC w/ Prepack Screen	Fugro	1839.39	-3154.3	1,926,949.2	1,031,926.5	798.69	798.7		798.29		31.9	36.9	766.8	761.8	59.96	738.73	
CP-59	CPT	3/4" PVC w/ Prepack Screen	Fugro	1732.38	-2623.0	1,926,839.7	1,032,457.4	796.6	796.65		796.23		29.0	44.0	767.6	752.6	66.98	729.62	
CP-60	CPT	3/4" PVC w/ Prepack Screen	Fugro	2420.04	-3768.3	1,927,532.6	1,031,315.2	803.65	803.67		803.28		30.0	50.0	773.7	753.7	61.4	742.25	
CP-60S	Casing Driven Only (No Cone)	3/4" PVC w/ Prepack Screen	Fugro	2421.44	-3768.1	1,927,534.0	1,031,315.4	803.76	803.77		803.39		10.0	20.0	793.8	783.8	20.0	783.76	No Sounding Completed. Refer to CP-60
CP-61	CPT	3/4" PVC w/ Prepack Screen	Fugro	2689.83	-3963.1	1,927,783.3	1,031,121.5	806.11	806.19		805.82		41.0	56.0	765.1	750.1	62.98	743.13	

Table 1

Summary of Offsite Gas Migration Investigation

Mallard Lake Landfill
Hanover Park, Illinois

Well Name	Description: Type of Borehole	Description: Well Construction	Description: Contractor	Site Coordinates: Northing	Site Coordinates: Easting	IL St. Plane E: Northing	IL St. Plane E: Easting	Ground Surface	Top of Flush Mount Casing	Top of PVC (for wells >2" dia.)	Mid Valve Elevation	Top of Valve Stem	Screen Interval: Top	Screen Interval: Bottom	Screen Interval: Top	Screen Interval: Bottom	Sounding Terminal Depth	Sounding Terminal Elevation	Notes
				(ft)	(ft)	(ft)	(ft)	(ft MSL)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	(ft bgs)	(ft bgs)	(ft msl)	(ft msl)	(ft msl)	(ft msl)	
CP-62	CPT	3/4" PVC w/ Prepack Screen	Fugro	1037.44	-1685.8	1,926,140.5	1,033,391.4	795.2	795.24		794.86		44.6	64.6	750.6	730.6	64.03	731.17	
CP-63	CPT	3/4" PVC w/ Prepack Screen	Fugro	1164.82	-1085.0	1,926,265.2	1,033,992.7	800.71	800.7		800.19		41.0	51.0	759.7	749.7	59.96	740.75	
CP-64	CPT	3/4" PVC w/ Prepack Screen	Fugro	1449.24	-687.0	1,926,547.8	1,034,392.1	803.89	803.93		803.56		51.5	61.5	752.4	742.4	64.49	739.40	
GX-01	CPT	3/4" PVC well	Stratigraphics	180.5	1271.0	1,925,279.2	1,036,344.3	803	803		802.68		40.0	45.0	763.0	758.0	49.0	754.00	
GX-02	CPT	3/4" PVC well	Stratigraphics	369.54	1295.9	1,925,459.1	1,036,370.0	816.86	816.94		816.62		56.5	61.5	760.4	755.4	69.0	747.86	
GX-03	CPT	3/4" PVC well	Stratigraphics	461.2	1370.8	1,925,550.4	1,036,445.3	800.63	800.57		800.14		44.0	49.0	756.6	751.6	63.0	737.63	
GX-04	CPT	3/4" PVC well	Stratigraphics	462.4	1162.0	1,925,552.6	1,036,236.5	801.65	801.6		801.57		39.2	44.2	762.5	757.5	56.0	745.65	
GX-05	CPT	3/4" PVC w/ Prepack Screen	Fugro	44.9	1162.5	1,925,135.1	1,036,235.1	802.31	802.31		802.34		42.0	52.0	760.3	750.3	53.99	748.32	
GX-06	CPT	3/4" PVC w/ Prepack Screen	Fugro	58.2	1291.2	1,925,147.8	1,036,363.9	802.31	802.31		801.77		45.0	50.0	757.3	752.3	53.92	748.39	
GX-07	CPT	3/4" PVC w/ Prepack Screen	Fugro	78.5	1433.2	1,925,167.4	1,036,506.0	801.43	801.43		800.87		49.0	54.0	752.4	747.4	59.96	741.47	
GX-08	CPT	3/4" PVC w/ Prepack Screen	Fugro	286.36	2721.3	1,925,369.4	1,037,795.0	792.61	792.69		792.25		37.0	52.0	755.6	740.6	69.01	723.60	
GX-09	CPT	3/4" PVC w/ Prepack Screen	Fugro	282.26	2371.3	1,925,366.9	1,037,445.0	795.82	795.82		795.4		38.0	53.0	757.8	742.8	65.93	729.89	
GX-10	CPT	3/4" PVC w/ Prepack Screen	Fugro	287.98	2536.4	1,925,371.9	1,037,610.1	793.83	793.87		793.5		42.8	47.8	751.0	746.0	62.98	730.85	
GX-11	CPT	3/4" PVC w/ Prepack Screen	Fugro	273.31	2255.5	1,925,358.5	1,037,329.2	796.04	796.04		795.68		37.2	47.2	758.8	748.8	61.01	735.03	
GX-12	CPT	3/4" PVC w/ Prepack Screen	Fugro	152.17	2150.0	1,925,237.8	1,037,223.1	796.45	796.43		796.05		55.0	65.0	741.5	731.5	64.94	731.51	
GX-13	CPT	3/4" PVC w/ Prepack Screen	Fugro	175.87	2348.8	1,925,260.6	1,037,422.0	795.42	795.47		795.09		38.0	54.0	757.4	741.4	55.04	740.38	
GX-14	CPT	3/4" PVC w/ Prepack Screen	Fugro	188.5	2492.2	1,925,272.6	1,037,565.5	794.79	794.76		794.41		44.0	54.0	750.8	740.8	54.32	740.47	
RW-01	CPT	3/4" PVC w/ Prepack Screen	Fugro	2640.7	-1008.0	1,927,740.7	1,034,076.5	811.01	811.01		810.42		43.5	58.5	767.5	752.5	62.91	748.10	
RW-03	CPT	3/4" PVC well	Stratigraphics	2636.43	-1079.5	1,927,736.8	1,034,004.9	810.68	810.69		810.16		40.0	50.0	770.7	760.7	63.5	747.18	
RW-03D	CPT	3/4" PVC w/ Prepack Screen	Fugro	2634.91	-1087.5	1,927,735.3	1,033,996.9	810.96	810.94		810.5		52.0	62.0	759.0	749.0			
RW-03I	Geoprobe	1" PVC well	Terra Trace	2636.36	-1083.0	1,927,736.7	1,034,001.4	810.86	810.84		810.42		32.0	37.0	778.9	773.9	37.0	773.86	
RW-03S	Geoprobe	1" PVC well	Terra Trace	2629.78	-1078.8	1,927,730.1	1,034,005.6	810.7	810.71		810.22		7.0	12.0	803.7	798.7	12.0	798.70	
RW-04	CPT	3/4" PVC well	Stratigraphics	2631.4	-1308.5	1,927,732.8	1,033,775.9	810.68	810.68		810.34		45.0	65.0	765.7	745.7	67.0	743.68	
RW-04S	Geoprobe	1" PVC well	Terra Trace	2632.4	-1313.4	1,927,733.8	1,033,771.1	810.72	810.89		810.52		4.0	10.0	806.7	800.7	12.0	798.72	
RW-05	CPT	3/4" PVC well	Stratigraphics	2945.33	-1494.7	1,928,047.5	1,033,591.1	810.12	810.2		809.8		42.0	52.0	768.1	758.1	59.5	750.62	
RW-05S	Geoprobe	1" PVC well	Terra Trace	2948.03	-1490.7	1,928,050.2	1,033,595.1	810.37	810.39		810.02		4.0	10.0	806.4	800.4	12.0	798.37	
RW-05I	4" O.D. Wash Bore Rotary	2" PVC well	SEI	2951.01	-1486.5	1,928,053.2	1,033,599.4	810.47	810.54	810.36	N/A		14.0	24.0	796.5	786.5	25.0	785.47	Refer to Stratigraphics log RW-5
RW-06	CPT	3/4" PVC w/ Prepack Screen	Fugro	2652.7	-1753.4	1,927,756.1	1,033,331.1	807.44	807.44		807.03		50.0	60.0	757.4	747.4	65.93	741.51	
RW-07	CPT	3/4" PVC w/ Prepack Screen	Fugro	2661.5	-2115.9	1,927,766.5	1,032,968.7	802.6	802.5		802.17		37.5	42.5	765.1	760.1	42.25	760.35	
RW-08	CPT	3/4" PVC w/ Prepack Screen	Fugro	3005	-2054.3	1,928,109.8	1,033,031.8	803.02	803.02		802.79		43.0	48.0	760.0	755.0	52.87	750.15	
RW-09	CPT	3/4" PVC w/ Prepack Screen	Fugro	3011.6	-1797.9	1,928,115.2	1,033,288.3	805.8	805.8		805.33	805.56	41.0	46.0	764.8	759.8	50.12	755.68	
RW-10	CPT	3/4" PVC w/ Prepack Screen	Fugro	3284.3	-1806.4	1,928,387.9	1,033,281.0	804.89	804.89		804.51	804.7	41.0	46.0	763.9	758.9	53.92	750.97	
RW-11	CPT	3/4" PVC w/ Prepack Screen	Fugro	3272.1	-2040.6	1,928,376.8	1,033,046.8	799.48	799.48		798.94		44.0	54.0	755.5	745.5	57.07	742.41	
RW-12	CPT	3/4" PVC w/ Prepack Screen	Fugro	3191.4	-2348.1	1,928,297.5	1,032,738.9	800.54	800.54		800.2		38.0	48.0	762.5	752.5	49.99	750.55	
RW-13	CPT	3/4" PVC w/ Prepack Screen	Fugro	3459.8	-2417.5	1,928,566.2	1,032,670.7	801.87	801.87		801.35	801.68	37.0	47.0	764.9	754.9	49.92	751.95	
RW-14	CPT	3/4" PVC w/ Prepack Screen	Fugro	3526.1	-2136.7	1,928,631.2	1,032,951.8	795.45	795.45		795.01	795.3	44.0	54.0	751.5	741.5	62.58	732.87	
RW-15	CPT	3/4" PVC w/ Prepack Screen	Fugro	3583.4	-1795.3	1,928,687.0	1,033,293.5	796.27	796.27		795.75	795.9	26.0	36.0	770.3	760.3	36.41	759.86	
RW-16	CPT	3/4" PVC w/ Prepack Screen	Fugro	2776.3	-1493.0	1,927,878.5	1,033,592.1	811.46	811.46		810.97	811.32	51.0	61.0	760.5	750.5	61.07	750.39	
RW-17	CPT	3/4" PVC w/ Prepack Screen	Fugro	3067.8	-1373.4	1,928,169.5	1,033,713.0	813.98	813.98		813.53	813.61	45.0	55.0	769.0	759.0	61.14	752.84	
RW-18	CPT	3/4" PVC w/ Prepack Screen	Fugro	2959.6	-2362.0	1,928,065.8	1,032,723.9	799.41	799.41		799.16		41.0	51.0	758.4	748.4	56.22	743.19	
RW-19	CPT	3/4" PVC w/ Prepack Screen	Fugro	2720.8	-2346.7	1,927,826.9	1,032,738.1	801.55	801.66		801.32		39.0	54.0	762.6	747.6	57.93	743.62	
RW-20	CPT	3/4" PVC w/ Prepack Screen	Fugro	3106.2	-2207.5	1,928,211.7	1,032,879.1	801.37	801.37		800.94		42.0	52.0	759.4	749.4	53.92	747.45	
RW-21	CPT	3/4" PVC w/ Prepack Screen	Fugro	2984.1	-1111.1	1,928,084.6	1,033,974.9	817.95	817.95		817.65	817.81	46.5	61.5	771.5	756.5	61.27	756.68	
RW-22	CPT	3/4" PVC w/ Prepack Screen	Fugro	2911.23	-2817.9	1,928,019.5	1,032,267.8	807.35	807.43		807.07		39.0	49.0	768.4	758.4	54.91	752.44	
RW-23	CPT	3/4" PVC w/ Prepack Screen	Fugro	2918.13	-3156.0	1,928,027.9	1,031,929.8	806.93	807.05		806.67		44.0	54.0	762.9	752.9	59.96	746.97	Refer to Fugro log RW-23T2
RW-24	CPT	3/4" PVC w/ Prepack Screen	Fugro	2950.22	-3391.1	1,928,061.1	1,031,694.8	805.21	805.22		804.89		39.7	49.7	765.5	755.5	66.06	739.15	
RW-25	CPT	3/4" PVC w/ Prepack Screen	Fugro	2925.9	-3719.7	1,928,038.2	1,031,366.1	806.75	806.91		806.57		44.0	59.0	762.8	747.8	65.01	741.74	
RW-26	CPT	3/4" PVC w/ Prepack Screen	Fugro	3241.82	-2975.3	1,928,350.8	1,032,111.9	802.2	802.28		801.95		36.0	51.0	766.2	751.2	56.02	746.18	
RW-27	CPT	3/4" PVC w/ Prepack Screen	Fugro	3239.27	-3481.0	1,928,350.5	1,031,606.2	799.59	799.72		799.4		41.0	46.0	758.6	753.6	67.5	732.09	
RW-28	CPT	3/4" PVC w/ Prepack Screen	Fugro	2869.87	-3893.8	1,927,983.0	1,031,191.7	808.16	808.22		807.89		49.0	59.0	759.2	749.2	71.96	736.20	
ML-1	CPT	3/4" PVC w/ Prepack Screen	Fugro	737.75	5458.1	1,925,808.4	1,040,533.8	789.12	789.14		788.78		40.2	50.2	748.9	738.9	57.93	731.19	
ML-2	CPT	3/4" PVC w/ Prepack Screen	Fugro	2392.96	4432.3	1,927,468.2	1,039,515.5	777.73	777.79		777.47		28	33	749.7	744.7	50.05	727.68	
ML-3	CPT	3/4" PVC w/ Prepack Screen	Fugro	3688.21	5341.1	1,928,759.3	1,040,430.3	792.73	792.79		792.44		29.0	39.0	763.7	753.7	53.92	738.81	
ML-6	CPT	3/4" PVC w/ Prepack Screen	Fugro	5702.34	1616.9	1,930,790.4	1,036,715.2	792.95	792.95		792.56		48	53	745.0	740.0	53.6	739.35	
ML-7	CPT	3/4" PVC w/ Prepack Screen	Fugro	2067.04	6152.6	1,927,134.5	1,041,234.4	789.06	789.11		788.78		39	49	750.1	740.1	55.17	733.89	
GPT-1	CPT	3/4" PVC w/ Prepack Screen	Fugro	2012.67	200.9	1,927,107.2	1,035,282.5	816.49	816.46		816.11		46	61	770.5	755.5	61.01	755.48	
GPT-2	CPT	3/4" PVC w/ Prepack Screen	Fugro	2739.94	-382.1	1,927,837.1	1,034,702.9	823.15	823.17		822.86		52.1	57.1	771.1	766.1	56.02	767.13	
GPT-3	CPT	3/4" PVC w/ Prepack Screen	Fugro	3131.4	-873.9	1,928,230.8	1,034,212.8	799.78	799.87		799.46		28.1	48.1	771.7	751.7	47.89	751.89	
GPT-4	CPT	3/4" PVC w/ Prepack Screen	Fugro	4204.71	1318.8	1,929,294.1	1,036,410.3	769.73	769.72		769.51		10.7	20.7	759.0	749.0	20.47	749.26	
GPT-5	CPT	3/4" PVC w/ Prepack Screen	Fugro	3846.24	1250.4	1,928,936.0	1,036,340.3	769.76	769.78		769.48		6	11	763.8	758.8	10.89	758.87	
GPT-6	CPT	3/4" PVC w/ Prepack Screen	Fugro	3423.63	1127.1	1,928,513.9	1,036,215.1	773.09	773.03		772.63		20.5	30.5	752.6	742.6	29.78	743.31	
TW-1	10" OD Wash Bore Rotary	6" Dia. Sch. 40 PVC Test Well	Meadows Equip.	232.47	1251.2	1,925,322.2	1,036,324.7	803.11	No Casing	805.93	N/A	N/A	52.5	38.6	750.6	764.5	54.2	748.91	Blind Rotary Drill (See GX-1)
SE corner of East Pond	Bench Mark for SW Readings	Surface Water Monitoring Location		1303.29	-2398.7			784.02	Spray painted orange dot on top(mid) of concrete structure										
Middle of	Bench Mark for SW Readings	Surface Water Monitoring Location		1331.76	-2725.4			784.41	Spray painted orange dot on top(mid) of concrete structure										
NW corner of	Bench Mark for SW Readings	Surface Water Monitoring Location		1426.14	-3245.6			796.44	Spray painted orange dot on top(mid) of metal grate structure										

Notes
Survey data provided by Weaver Boos, Naperville, IL
For all CPT wells, the Mid-Valve elevation is the point at which depth to groundwater measurements are taken.
The Top of PVC elevation are point at which depth to groundwater measurements are taken in 2" PVC wells and larger.
Well s indicated as inaccessible will be resurveyed once snow and ice piles are removed.
Refer to Appendix B for well completion reports

TABLE 2

Summary of Field Measurements

TW-1 Radius of Influence Test

Mallar Lake Landfill

Hanover Park, Illinois

Well Head Readings - Discharge of Water Quality at TW-1

Date	Time (24hr)	Flow Rate	Water Quality Indicator Parameters				Notes / Comments
			pH	Conductivity	Turbidity	Temp.	
		gpm	(s.u.)	(umhos/cm)	(ntu)	(deg. C)	
2/13/2008	14:00	Static Water Level = 44.01 ft btoc					
---	16:26	Start Pumping					
---	19:00-19:30	0.31	6.57	572	4	9.7	(5 gals. / 16 min.)
---	23:15	0.38	---	---	---	---	(5 gals. / 16 min.)
2/14/2008	06:00	0.42	6.72	549	2	9.5	(5 gals / 12 min.)
---	10:05	0.31	6.86	553	4	9	(5 gals. / 16 min.)
---	13:35-13:50	0.33	7.14	542	12	9.4	(5 gals/ 15 min.)
---	15:29-15:54	0.33	7.11	541	---	9.7	(5 gals/ 15 min.)
2/15/2008	09:00	0.29	7.38	539	---	8.1	(5 gals/ 17 min.)
---	15:06	0.25	7.43	529	---	8.7	(5 gals/ 20 min.)
---	17:05	Pumping rate begins to slow due to discharge line freezing within the wellhead.					
2/16/2008	03:00	Water level in well recovers to static conditions.					

Well Head Readings - Gas Measurements in Head Space

Well	Date	Time (24hr)	CH4	CO2	O2	Static Pressure	Depth to Water[1]
			(%)	(%)	(%)	(psi)	(ft btoc)
TW-1	3/13/2008	23:10	30	0.5	13	atm.	48.85
	3/14/2008	8:25	33.8	0.9	12.2	atm.	50.99
	"	12:40	31.1	0.9	13.1	atm.	52.87
	"	17:20	49.8	1.2	8.3	atm.	52.89
	3/15/2008	7:54	0	0	21.8	atm.	52.87
	"	13:35	0	0	21.6	atm.	52.87
	"	14:53	0	0	21.7	atm.	52.87
GX-1	3/13/2008	19:04	34.8	1	11.7	-0.01	41.53
	3/14/2008	8:19	3.6	0.2	20.8	0	41.64
	"	12:45	16.7	0.5	16.6	0	41.58
	"	17:26	10.2	0.3	18.3	-0.01	41.63
	3/15/2008	8:05	6	0.3	20.1	-0.03	41.87
	"	14:41	5	0.1	19.9	-0.01	41.78
P6B	3/13/2008	17:46	77.6	3.5	0	-0.14	41.16
	3/14/2008	8:36	78.9	4	0	-0.14	41:16
	"	13:21	81.2	4	0	-0.15	41.18
	"	17:38	81.3	4	0	-0.01	41.16
	3/15/2008	7:40	74.9	3.8	0	-0.02	---
	"	15:08	72.4	3.6	0	-0.02	41.15

Notes:

1. Depth to water measurements were taken from the LevelTroll transducers for TW-1 and GX-1. Water levels at P6B were monitored manually because of the limited saturated thickness within the well.
2. Head space gas measurements were made at other observation wells during the TW-1 ROI test (i.e. P6A, GX-2, GX-5, GX-6 & GX-7), but no other wells besides TW-1, GX-1 and P6B had methane detected.

Summary of Radius of Influence Phase 1 Results
Mallard Lake Landfill
STS Project No 200704805

Probe	Test Start							Test End							Comments
	Date	Time	Pressure (in H_2O)	CH_4 (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Date	Time	Pressure (in H_2O)	CH_4 (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	
Header	2/13/2008	3:49 PM	-60.4	8.2	4.1	18.7	69.3								
PV-1	2/7/2008	10:40 AM	1	75.1	24.9	0	0	2/7/2008	10:50 AM	8.8	Not Measured				
PV-2	2/7/2008	11:13 AM	-10	0	0.3	20	79.7	2/7/2008	11:14 AM	0	Not Measured				
PV-3	2/7/2008	11:25 AM	-29	Not Measured				2/7/2008	11:35 AM	-28.8	0	0.7	20	79.3	
PV-4	2/7/2008	11:54 AM	-16	Not Measured				2/7/2008	11:56 AM	-1.8	0	0	20.3	79.9	
PV-5	2/7/2008	12:14 PM	-9.6	1.7	1.1	19.4	77.7	2/7/2008	12:16 PM	0	Not Measured				
PV-6	2/7/2008	2:18 PM	-57.2	54.9	28.9	4	10	2/7/2008	2:38 PM	0	15.3	8	15.9	60.6	
PV-7	2/7/2008	2:49 PM	-57.4	0	0	20.6	79.4	2/7/2008	3:08 PM	-1	0.4	0.3	20.5	78.7	
PV-8	2/7/2008	3:17 PM	-57.6	39.3	24.2	7.5	23.5	2/7/2008	3:37 PM	-5.2	0.3	0.3	20.3	79.2	
PV-9	2/7/2008	3:57 PM	0	Not Measured				Not Measured							well being vented
PV-10	2/7/2008	4:29 PM	-57	0	0.2	20.5	79.3	2/7/2008	4:41 PM	-0.3	0	0	20.6	79.4	
PV-11	2/7/2008	4:45 PM	-57.8	0.5	0.6	19.5	79.4	2/7/2008	5:00 PM	0	0.3	0.5	19.8	79.3	
PV-12	2/13/2008	1:45 PM	-47.4	0	0	20.9	79.1	2/13/2008	1:54 PM	0	0	0	20.8	79.2	
PV-13	2/13/2008	2:12 PM	-50.3	0	0	20.8	79.2	2/13/2008	2:58 PM	-2.1	5.7	0.9	19.1	74.3	
PV-14	2/13/2008	3:07 PM	-50.6	0	0	20.9	79.1	2/13/2008	3:10 PM	0	6.8	2.1	19.5	71.5	

Notes:
Refer to Appendix G1 for Field Notes

Summary of Grain Size Analyses
Mallard Lake Landfill
STS Project No 200704805

Sample	Elevation (ft MSL)	Description	Grain size							Representative Strata
			% Gravel		% Sand			% Fines		
			Coarse	Fine	Coarse	Medium	Fine	Silt	Clay	
CP-20D	779.3-777.3	Gray Silty Clay Trace Medium Sand	0	0.5	0.6	2.4	3.7	24.5	68.3	Till above W1/W2
LDE-1	759-753	Brownish Gray Clayey Silt Trace Fine Sand	0	0	0.3	0.8	5.6	71.1	22.2	W1/W2
CP-20D	756.3-753.8	Gray Silty Clay Little Fine Sand Trace Gravel	0	7.6	2.7	4.3	7.6	34.3	43.5	Till below W1/W2

Notes:
Refer to Appendix A5 for Particle Size Distribution Reports

Table 5
Summary of Offsite CPT Probe Methane Detections
Mallard Lake Landfill
STS Project No 200704805

Probe	Date	Parameter				
		Methane (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Static Pressure (inches H_20)
CP-01	11/7/2007	0	0	21	79	NM
	11/8/2007	5.9	0.2	19	74.8	NM
	11/9/2007	75.3	0.9	0.2	23.5	NM
	11/13/2007	79.8	1.1	0	19.1	24.4
	11/23/2007	79	1.6	0	19.4	13.7
	11/26/2007	86	1.6	0	12.6	20
	11/27/2007	0	0.4	21.3	78.4	NM
	12/6/2007	80.4	2.5	0	17.1	19
	12/20/2007	79.3	1.3	0	19.1	19
	1/25/2008	90	1.3	0	8.4	16.3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	12.2
CP-02	11/8/2007	71	3.2	0	0	NM
	11/13/2007	80.3	3.1	0	16.7	25.2
	11/23/2007	77.8	3.3	0	18.8	6
	11/26/2007	85	4	0	10.7	17.8
	11/27/2007	0	0.6	21.1	78.3	NM
	12/6/2007	79.6	4.3	0	16.2	8
	12/19/2007	78.8	3.6	0	17.7	11.4
	1/18/2008	76.1	4.7	0	19.2	10.4
	1/25/2008	88	4.9	0	7.4	5.8
	2/14/2008 through 2/16/08	NM	NM	NM	NM	9.8
	3/11/2008	84.6	6.3	0	9.1	2.2
CP-04	11/9/2007	78.4	3.4	2.2	16.1	NM
	11/10/2007	78.4	3.4	2.2	16.1	NM
	11/13/2007	79.9	2.9	0	17.1	25.9
	11/26/2007	83.7	3.5	0	13	16.8
	11/27/2007	0	0.2	21.3	78.4	NM
	12/6/2007	81.4	4	0	14.8	0
	12/19/2007	79.3	3.2	0	17.6	9.8
	1/18/2008	76.5	3.1	0	20.4	16.4
	2/14/2008 through 2/16/08	NM	NM	NM	NM	12.6
	3/6/2008	82.5	4.7	0	13.8	7.1
CP-05	11/8/2007	0	0.2	21	78.7	NM
	11/9/2007	0	0.1	21	78.9	NM
	11/13/2007	0	0.1	20.2	79.7	0
	12/6/2007	0	0.1	20.9	79	0
	12/10/2007	0.4	0.1	19.7	79.8	0.5
	12/19/2007	0	0	21.5	78.5	-0.4
	1/10/2008	0	0	21.1	78.9	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-1.2
CP-05S	12/4/2007	0.6	0.5	19.8	79.1	0
	12/6/2007	0	0.2	21	78.8	0
	12/10/2007	0	0	21.2	78.8	0.5
	12/12/2007	0.6	0.3	21	78.2	-14.4
	12/19/2007	0.8	0.5	20.8	78.4	-0.2
	1/10/2008	0	0	21	79	1
	2/14/2008 through 2/16/08	NM	NM	NM	NM	1
	3/19/2008	0	0	21	79	0
	3/20/2008	0	0	21.7	78.3	0
	3/21/2008	0	0	20.2	79.8	0
	3/24/2008	0	0	20.7	79.3	0
	3/26/2008	0	0	20.5	79.5	0
	4/1/2008	0	0	20.8	79.2	0
CP-07	12/8/2007	0	0	21.1	79	0
	12/10/2007	13.4	0.4	13.9	72.2	0.4
	12/19/2007	0	0	21.7	78.3	0.3
	1/10/2008	2.5	4.2	8.7	84.6	3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0.5

Table 5
Summary of Offsite CPT Probe Methane Detections
Mallard Lake Landfill
STS Project No 200704805

Probe	Date	Parameter				
		Methane (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Static Pressure (inches H_2O)
CP-08	12/7/2007	72.8	1.5	1.4	24.4	0
	12/10/2007	74.2	1.5	0	24.3	0.3
	12/19/2007	77.9	1.6	0	20.5	2
	1/10/2008	78.9	1.6	0.1	19.4	1.6
	2/14/2008 through 2/16/08	NM	NM	NM	NM	7.8
CP-12	11/8/2007	0	0.2	20.9	78.9	NM
	11/9/2007	0	0.1	21	78.9	NM
	11/13/2007	0.1	0	20.8	79.1	-0.6
	11/27/2007	0	0.1	21.2	78.7	0
	12/6/2007	0	0.1	19.9	80	0
	12/20/2007	0	0	21.5	78.5	0
	1/25/2008	0	0	21.1	78.9	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-5.8
	3/6/2008	0	0.1	20.5	79.4	0.6
CP-14	12/15/2007	78.7	9.8	1.7	10.4	0
	12/17/2007	79.4	8.9	0	11.5	23.2
	12/20/2007	78.6	8.5		12.7	25
	1/10/2008	79.1	8.2	0.1	12.9	23
	2/22/2008	81.3	10.4	0	8.3	17.4
	2/14/2008 through 2/16/08	NM	NM	NM	NM	20.6
CP-15	12/14/2007	78.1	4.1	0.2	17.6	0
	12/20/2007	79	4	0	16.4	25.5
	1/10/2008	78.8	7.1	0	14.2	4.3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	16.5
	3/12/2008	75.7	8.3	0.4	14.8	NM
CP-16	12/20/2007	78	1.1	0	21	22.8
	1/10/2008	73.7	1	0	25.2	25.6
	2/22/2008	81.4	1.3	0	17.3	2.3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	17.1
CP-18	12/14/2007	78.7	0.7	1	19.7	0
	12/20/2007	67.4	0.3	3.1	28.4	22.2
	1/15/2008	80	0.07	0	19.5	1.4
	2/22/2008	81.6	1.1	0	17.3	7.8
	2/14/2008 through 2/16/08	NM	NM	NM	NM	11
CP-19	12/14/2007	0	0	21.1	78.9	0
	12/20/2007	0.6	0	19.8	79.6	19.7
	1/15/2008	0	0	20.5	79.5	1
	2/14/2008 through 2/16/08	NM	NM	NM	NM	2.4
	3/12/2008	0	0	21.3	78.7	0
CP-20	12/16/2007	0	0	21.9	78.1	NM
	12/20/2007	73.7	1.4	0	24.9	18.4
	1/14/2008	74.2	1.6	0.4	23.8	8.4
	2/22/2008	36.1	0.8	10.6	52.5	0.2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	13.4
CP-20D	1/30/2008	8.4	0	16.8	74.5	6
	2/14/2008 through 2/16/08	NM	NM	NM	NM	32.1
CP-22	12/20/2007	0	0.1	20.3	79.8	3.8
	1/10/2008	0.2	0.6	14.7	84.7	24
CP-23	12/16/2007	65.8	0.8	2.3	31.6	0
	12/20/2007	71.1	0.9	0	28	17.6
	1/14/2008	77.1	1.1	0	21.7	3.1
	2/14/2008 through 2/16/08	NM	NM	NM	NM	11.3
CP-24	12/20/2007	0	0	21.3	78.7	1
	1/10/2008	0.4	0.1	10.1	89.1	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-0.1
CP-26	1/14/2008	6.9	0.2	17.7	75.2	0
	2/22/2008	55.2	1.1	2.2	41.5	3.9
	3/11/2008	61	0.9	0.1	38	7.2

Table 5
Summary of Offsite CPT Probe Methane Detections
Mallard Lake Landfill
STS Project No 200704805

Probe	Date	Parameter				
		Methane (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Static Pressure (inches H_20)
CP-27	1/15/2008	73.2	1.1	0	25.6	1.4
	2/14/2008 through 2/16/08	NM	NM	NM	NM	7.9
CP-28	1/15/2008	36.9	0.8	0	62.1	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	4.1
	3/11/2008	40.9	0.9	0.4	58.1	0
CP-29	1/9/2008	0.6	0	20.4	79.2	0
	1/14/2008	47.7	1.2	2.5	48.7	2.2
	2/22/2008	48	1.3	0	50.7	4.6
	2/14/2008 through 2/16/08	NM	NM	NM	NM	6.5
CP-30	1/8/2008	59.4	1.4	1.4	38	0
	1/14/2008	0	0	20.2	79.8	0
	2/14/2008 through 2/16/08					9
	3/11/2008	0	0	20.4	79.6	2
CP-30S	1/14/2008	9.2	0.2	17.7	73	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0.4
CP-32	1/8/2008	0	0	20.7	79.3	0
	1/15/2008	47.3	0.6	0	52	24.2
	2/22/2008	29.6	0.5	9	60.9	2.7
	2/14/2008 through 2/16/08	NM	NM	NM	NM	13.4
CP-33	1/9/2008	37.4	1.2	1.8	59.9	NM
	1/14/2008	0	0	20.3	79.7	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-0.2
CP-33S	1/9/2008	39.9	1.4	1.7	57.3	0
	1/14/2008	38.7	1.5	0	59.7	11.2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	8.6
	3/12/2008	33.6	1.9	0	64.4	NM
CP-37	1/14/2008	78.5	1.4	0.1	20.1	2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	4
CP-38	1/8/2008	57.9	0.8	5.7	35.9	0
	1/14/2008	79.3	1.3	0.2	19.2	8.2
	2/22/2008	28.8	0.5	12.7	58.1	0.6
	2/14/2008 through 2/16/08	NM	NM	NM	NM	2.1
	3/12/2008	19.2	0.4	15.2	65.4	0.1
CP-40	1/14/2008	16.5	0.3	15.8	67.1	NM
	2/22/2008	44.4	0.9	6.9	47.6	0.9
	2/14/2008 through 2/16/08	NM	NM	NM	NM	3.2
CP-43	1/14/2008	10.4	0.5	15	74.1	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	3.7
CP-47	1/15/2008	25.8	0.4	12.3	61.4	0
	1/29/2008	0.1	0	21	79	NM
	2/22/2008	53.4	2.6	0	44	3.2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-2.8
	3/10/2008	55.4	2.2	0.8	41.6	0.8
CP-48	1/22/2008	13.1	1.2	8.9	76.7	0
	1/29/2008	0	0	20.8	79.2	NM
	2/22/2008	17	2.6	1.2	79.2	2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	2.8
CP-54	1/15/2008	6.2	1.2	0.5	92.1	0
	1/29/2008	0	0	21	79	NM
	2/22/2008	0	0	20.2	79.8	0.2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0.1
CP-55	1/15/2008	6.4	1.4	0.3	92	0
	1/29/2008	0	0	21	79	NM
	2/22/2008	0	0	20.3	79.7	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-0.1
	3/11/2008	0	0	20.4	79.6	0.4

Table 5
Summary of Offsite CPT Probe Methane Detections
Mallard Lake Landfill
STS Project No 200704805

Probe	Date	Parameter				
		Methane (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Static Pressure (inches H_20)
RW-03	11/9/2007	0	1	2.4	0	NM
	11/10/2007	79.3	0.9	0.4	19.7	NM
	11/13/2007	81.6	0.9	0	17.7	27.5
	11/23/2007	51.8	1	0	47.4	20
	11/27/2007	53.6	1.1	0	45.3	22.5
	12/6/2007	78.3	1.1	0	20.3	19.6
	12/20/2007	39	0.9	0	60.2	20.7
	1/25/2008	34.9	0.6	0.4	64.1	7.8
	2/14/2008 through 2/16/08	NM	NM	NM	NM	10.1
RW-03D	12/10/2007	80.1	0.9	2.7	16.7	0
	12/20/2007	0	0	21.2	78.8	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0.4
RW-04	11/10/2007	68.2	0.8	0.7	30.3	NM
	11/13/2007	69.8	0.8	0	27.4	27.4
	11/23/2007	72.3	0.8	0.2	26.6	4.4
	11/27/2007	73.2	0.8	0.5	25.3	13.3
	12/6/2007	78.6	0.8	0	20.6	15.3
	12/20/2007	75.8	0.5	0.1	23.6	0.6
	1/25/2008	4.5	0	20.1	75.5	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0
RW-04S	11/27/2007	0	0.4	21	78.6	0
	12/4/2007	0	0.1	21.4	78.5	0
	12/6/2007	0.2	1.1	19.9	78.9	0
	12/14/2007	0	0.7	19.7	79.5	-15.6
	12/20/2007	0	0.4	20.7	78.9	0
	1/25/2008	0	0	21.5	78.5	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0
RW-05	11/10/2007	24.7	0.5	13.1	57.9	NM
	11/13/2007	72.1	0.4	0	27.5	28.5
	11/23/2007	69.6	0.6	0	30.1	18.1
	11/27/2007	71.9	0.7	0	27.4	20
	12/6/2007	70.9	0.9	0	28	23.2
	12/19/2007	70.9	0.9	0	28	23.2
	12/20/2007	72.5	0.6	0	26.8	24.2
	1/15/2008	80.4	1	0	18.6	6.3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	3.5
	3/12/2008	77.4	1	0	21.6	NM
RW-07	12/17/2007	80.1	0.8	0.6	18.5	0
	12/20/2007	79.1	0.9	0	20.2	0
	1/15/2008	79.3	0.9	0.5	19.2	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0
RW-08	12/9/2007	32.6	0.6	7	59.3	0
	12/10/2007	48.4	1	0.4	50.2	21
	12/20/2007	64.5	1.1	0	34.6	1.4
	1/17/2008	48.2	0.9	2.7	48	3.7
	2/22/2008	37.7	0.9	5.7	55.7	0.2
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-7.4
	3/10/2008	52.8	0.8	3	43.4	1.8
RW-09	12/11/2007	27.4	0.2	12.2	60.1	0
	12/20/2007	66.1	0.5	0	33.4	22.2
	1/17/2008	66.7	0.5	0	32.9	14.1
	2/14/2008 through 2/16/08	NM	NM	NM	NM	9.4
RW-17	1/15/2008	0.4	0.1	16.9	82.6	1.4
	2/14/2008 through 2/16/08	NM	NM	NM	NM	0.2

Table 5
Summary of Offsite CPT Probe Methane Detections
Mallard Lake Landfill
STS Project No 200704805

Probe	Date	Parameter				
		Methane (%)	CO_2 (%)	O_2 (%)	Balance Gas (%)	Static Pressure (inches H_20)
GX-1	7/3/2007	72.1	0.7	0.3	26.9	NM
	2/22/2008	5.8	0	19.4	74.7	26.3
	2/14/2008 through 2/16/08	NM	NM	NM	NM	NM
	3/19/2008	2.7	0	19.7	77.9	0
	3/20/2008	1.2	0	20.7	78.2	0
	3/21/2008	1.4	0	20.2	78.3	0
	3/24/2008	1.9	0	20	78.1	0
	3/26/2008	0.6	0	20.2	79.2	0.1
	4/1/2008	0	0	20.8	79.2	0
GX-4	7/3/2007	1	1.1	20.3	77.6	NM
GX-9	1/23/2008	74.5	0.9	0.4	24	0
	2/22/2008	83.3	1.1	0	15.4	103
	2/14/2008 through 2/16/08	NM	NM	NM	NM	20.8
GPT-1	2/3/2008	0	0	20.7	79.3	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	-0.3
	3/19/2008	0.6	0	18.4	81	0
	3/20/2008	0.2	0	20.4	79.4	0.1
	3/21/2008	0.2	0	19.8	80.1	-0.1
	3/24/2008	0.3	0	19.3	80.4	0
	3/26/2008	0.1	0	20.1	79.8	0
	4/1/2008	0.2	0	19.7	80.1	-1
GPT-2	2/2/2008	28.7	0.2	13.7	58.1	0
	2/14/2008 through 2/16/08	NM	NM	NM	NM	2.1
	3/19/2008	23	0.1	15.1	63.1	1.5
	3/20/2008	16.5	0.1	16.9	67.5	1.5
	3/21/2008	20.5	0.2	15.5	64.5	1
	3/24/2008	12.7	0	17.6	70.2	0
	3/26/2008	7.1	0	19.1	74.2	0.2
	4/1/2008	16.4	0.1	17	67.4	0

Notes:
NM - Not Measured due to frozen quick disconnect valve
Only Static Pressures were recorded 2/14 to 2/16/08 in order to correct water levels. Refer to Appendix C for water level data

Table 6
Mallard Lake Landfill
Summa Canister Results for Detected Constituents

Parameter	Units	Sampled: 11/26-27/07							2/22/08																					3/20/2008		3/19/2008	
		Reporting Limits	CP-1	CP-2	CP-4	RW-3	RW-4	RW-5	Reporting Limits	CP-14	CP-14 Dup	CP-16	CP-18	CP-20S	CP-26	CP-29	CP-32	CP-38	CP-40	CP-47	CP-48	RW-8	GP-E	GP-P2C	GX-1	GX-9	GX-9 Dup	P-6B	Ambient Air	Reporting Limits	GX-1 Probe Blank	Reporting Limits	Flare A - Landfill Gas
1,2,4-Trimethylbenzene	PPBv	0.5							1																					1	1.5	20	
2-Butanone (MEK)	PPBv	0.5		1.2	0.89	0.57	1.8	1.5	2						16															1	21	20	1,000
4-Methyl-2-Pentanone (MIBK)	PPBv	0.5							1																					1		20	140
Acetone	PPBv	0.5	1.7	5	9.1	5.8	8.2	6.5	4							44	12	8.2		4.5	4.5				4.1	4.2				1	55	20	1,100
Benzene	PPBv	0.5							1						1															1	1.4	20	690
Carbon Disulfide	PPBv	0.5	2.4		0.61				1				11						21	84	6.3	26						8		1		20	
Cyclohexane	PPBv	0.5	0.58						1						1.6															1	2.4	20	240
Ethanol	PPBv	0.5	0.55	1.8	1	4.4	2.3	2.4	10					56	14															1	140	20	1,400
Ethyl Acetate	PPBv	0.5		1.1			1.1	1.2	1						8															1		20	200
Ethylbenzene	PPBv	0.5							1						1.2															1	3.3	20	810
Hexane	PPBv	0.5	1.6			2.2			1																8.5					1	43	20	520
Isopropanol	PPBv	0.5			0.6	3	0.64	0.67	1						7.3															1	25	20	1,000
m/p-Xylene	PPBv	0.5							2						2.4															1	9.8	20	1,100
n-Heptane	PPBv	0.5	0.81						1						3.9															1	5.7	20	380
Propene	PPBv	0.5							1												26	38								1		20	1,700
Styrene	PPBv	0.5					0.57	0.56	1																					1	3.2	20	
Tetrahydrofuran	PPBv	0.5							1																			3.2		1	7.4	20	600
Toluene	PPBv	0.5	0.84	1	0.61	0.6	1.5	1.3	1						150															1	7	20	3,000
1,1-Dichloroethane	PPBv	0.5							1																					1		20	52
1,1-Dichloroethylene	PPBv	0.5							1																					1		20	61
1,2-Dichloroethane	PPBv	0.5							1						5.4															1		20	
1,2-Dichloropropane	PPBv	0.5							1						24															1		20	
1,2-Dichlorotetrafluoroethane (114)	PPBv	0.5	240	9.6	6			6.1	1	410	350	29		2.6				2.3					120			24	22	190		1		20	25
1,4-Dichlorobenzene	PPBv	0.5							1																					1	1.3	20	
Chloroethane	PPBv	0.5							2																					1		20	37
Chloromethane	PPBv	0.5							2													5.9								1	2.8	20	26
cis-1,2-Dichloroethylene	PPBv	0.5							1																4.3					1	40	20	380
Dichlorodifluoromethane	PPBv	0.5	1.2						1	11	13												8.5					3.4		1		20	220
Methylene Chloride	PPBv	0.5				5.3			2						2.4															1		20	82
t-1,2-Dichloroethylene	PPBv	0.5							1																					1		20	
Tetrachloroethylene	PPBv	0.5							1			1.7		2	1.1	1.2						3.8			410					1	2,000	20	120
Trichloroethylene	PPBv	0.5							1																2.7					1	25	20	66
Vinyl Chloride	PPBv	0.5	8.5						1	230	180																	66		1		20	340
Total non-halogenated VOCs	PPBv	-	8.5	10	13	17	16	14	-	0	0	0	11	56	205	44	12	8.2	21	89	37	64	0	0	13	4.2	0	11	0	-	324	-	13,880
Total halogenated VOCs	PPBv	-	249.7	9.6	6	5.3	0	6.1	-	651	543	30.7	0	4.6	32.9	1.2	0	2.3	0	0	0	9.7	129	0	417	24	22	259	0	-	2,069	-	1,296
Total VOCs	PPBv	-	258.2	20	19	22	16	20	-	651	543	30.7	11	60.6	238	45.2	12	10.5	21	88.5	36.8	73.7	129	0	430	28.2	22	271	0	-	2,393	-	15,176
Methane	%	-	81	80	84	20	16	72	-	85.1	86.3	85.8	77.3	81.5	31.1	48.3	49.9	50.9	68.2	50.6	16.1	54.7	84.6	0.0	2.2	80	81.7	77.8	0.0	-	-	-	15
Carbon Dioxide	%	-	1.4	3.3	3.0	0.4	0.2	0.5	-	9.7	9.8	1.2	0.8	1.4	0.8	1.0	0.7	0.8	1.1	2.3	2.2	1.0	11	0.0	0.1	1.0	1.0	2.8	0.0	-	-	-	11
Oxygen	%	-	0.7	0.5	0.5	12.2	18.7	0.5	-	0.0	0.0	1.0	2.6	0.0	12.5	2.2	0.0	8.1	0.0	2.7	0.0	2.3	0.0	22.1	21.4	4.2	1.1	1.5	21.7	-	-	-	16
Nitrogen	%	-	11	8.8	9.7	65	69	24	-	6.0	6.1	15.2	21.4	16.4	58.8	50	36.7	37.6	27.7	42.6	68.9	44.1	3.0	78.5	78	21	10.4	14.3	77.4	-	-	-	58

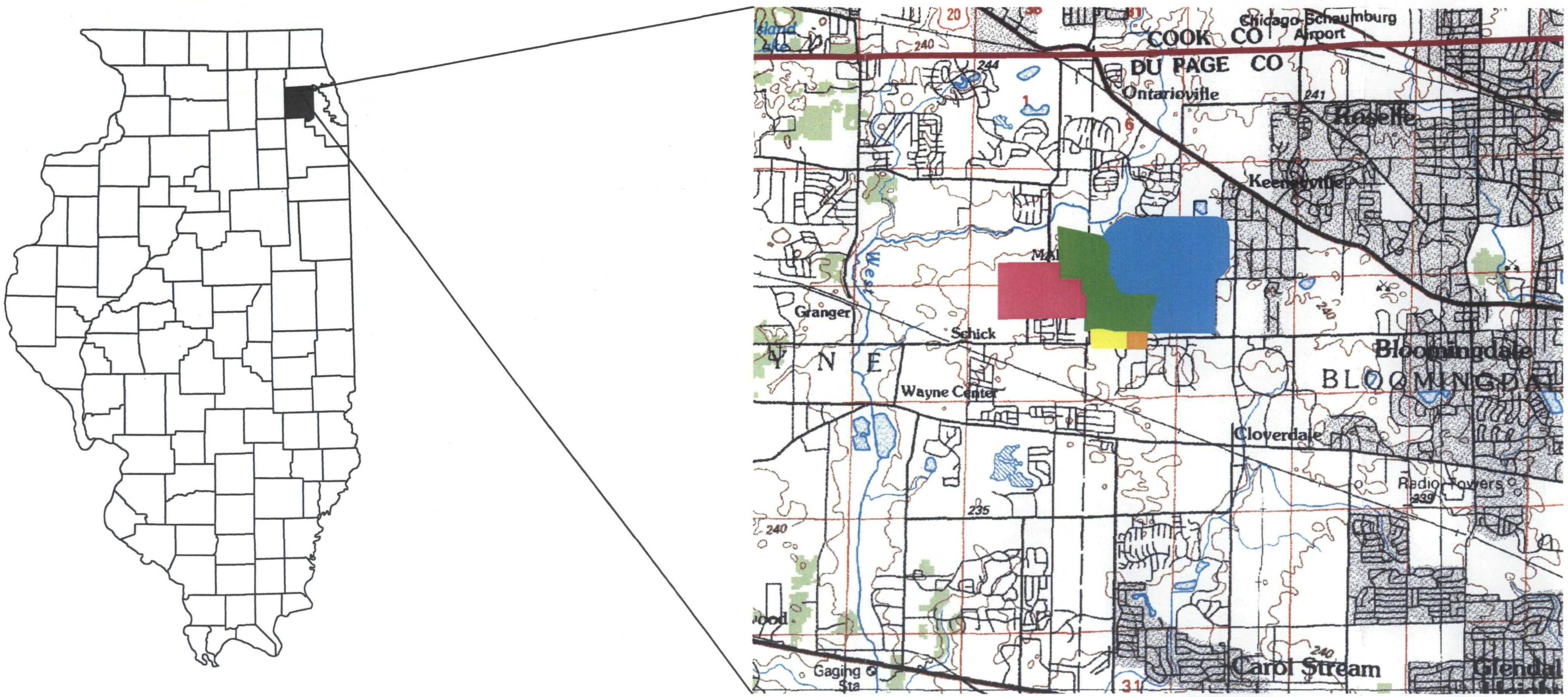
Notes: - An empty cell indicates a result below the detection limit, refer to Appendix D for a copy of the lab report.

Table 7
Mallard Lake Landfill
CPT Probe Groundwater Results
for Detected Constituents (ug/L)

Sample ID	Sample Date	Acetone	Carbon Disulfide	Chloro-methane	Methylene Chloride	Methyl Ethyl Ketone	Toluene	Tetrahydro-furan
Till AGQS		**10**	**100**	**5**	**5**	**20**	**5**	**20**
SWDA MCL		-	-	-	***5***	-	***1000***	-
Reporting Limit		**10**	**1**	**1**	**1**	**5**	**1**	**1**
CP-2	11/29/2007							NA
CP-2	3/11/2008						1.1	NA
CP-3	11/28/2007			1.3				NA
CP-4	3/6/2008	23		1		6.8		NA
CP-5	11/28/2007							NA
CP-9	11/29/2007							NA
CP-11	11/29/2007							NA
CP-12	11/29/2007	46			4.3			NA
CP-12	3/6/2008							NA
CP-12D	3/24/2008	24*				15.5*		33.9*
CP-15	3/12/2008							NA
CP-19	3/12/2008	33		2.6				NA
CP-26	3/11/2008	24						NA
CP-28	3/11/2008	27					1.4	NA
CP-30	3/11/2008							NA
CP-30 Dup	3/11/2008							NA
CP-33S	*3/12/2008*	32						NA
CP-35	3/12/2008							NA
CP-38	3/12/2008							NA
CP-47	3/10/2008							NA
CP-55	3/11/2008	18					1.4	NA
RW-26	3/10/2008							NA
RW-4	11/29/2007		1					NA
RW-4	3/10/2008							NA
RW-4 Dup	3/10/2008							NA
RW-4 MS	3/10/2008							NA
RW-4 MS Dup	3/10/2008							NA
RW-5	11/29/2007							NA
RW-5	3/12/2008	14					17	NA
RW-6	3/10/2008							NA
RW-8	3/10/2008							NA
Equipment Blank	3/10/2008							NA
Equipment Blank	3/11/2008							NA
Trip Blank	12/3/2007							NA
Trip Blank	3/12/2008							NA
Trip Blank	3/13/2008							NA

Notes:
- An empty cell indicates a result below the detection limit, refer to Appendix E for a copy of the lab report.
* - Component of PVC cement which was inadvertantly used by a drillers helper without approval.
NA - Not analyzed

Tables



Project Location Map

N

1 0 1 2
1" = 1 MILE

(pink)	WEST SIDE INVESTIGATION AREA (REFER TO DRAWING NO.4)
(yellow)	SOUTH SIDE WELL TW-1 INVESTIGATION AREA (REFER TO FIGURE 3)
(orange)	SOUTH SIDE PROBE GPE INVESTIGATION AREA (REFER TO FIGURE 4)
(blue)	EAST SIDE INVESTIGATION AREA (REFER TO DRAWING NO. 5)
(green)	LANDFILL
(outline)	COUNTY LINE

NOTES:

1) 15' TOPOGRAPHIC QUADRANGLE MAP COURTESY OF THE UNITED STATES GEOLOGICAL SURVEY

2) REFER TO REFERENCED FIGURES AND DRAWINGS FOR MORE DETAILED DESCRIPTION OF INVESTIGATION AREAS

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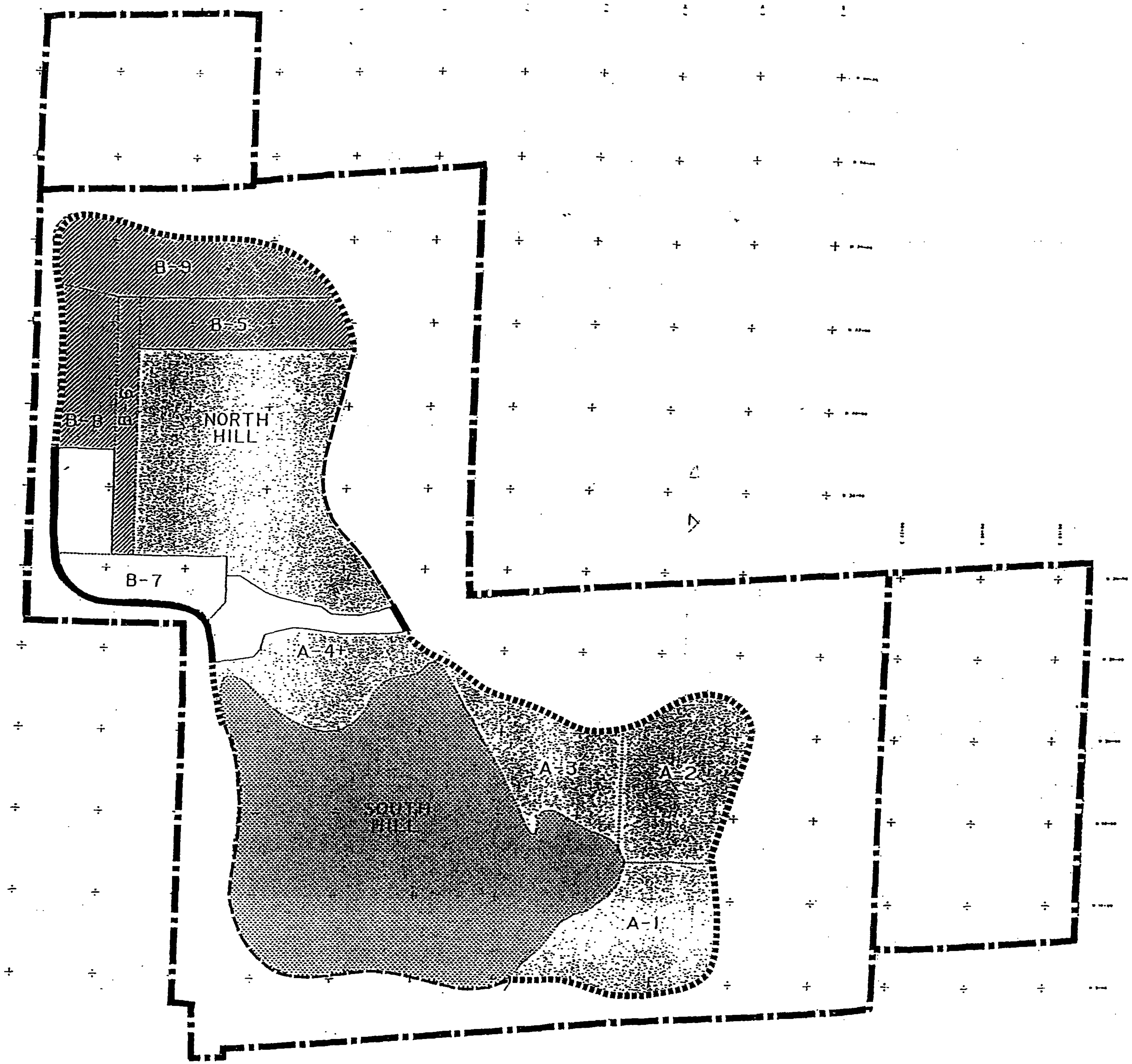
SITE LOCATION MAP DEPICTING INVESTIGATION AREA
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	MIB	03/27/2008
Checked:	GMB	03/27/2008
Approved:	CSR	03/27/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	1	

X:\PROJECTS\...807\G200704807-FIG1.dwg; 4/4/2008 11:04:46 AM; DEARMAN, DANIEL; STS.stb



LEGEND

APPROXIMATE PROPERTY BOUNDARY

SIDESEAL CONSISTING OF MINIMUM OF 10 FT. RECOMPACTED CLAY LINER

SIDESEAL CONSISTING OF COMPOSITE LINER (3 FT. RECOMPACTED CLAY AND GEOMEMBRANE)

IN-SITU LOW PERMEABILITY SOIL SIDESEAL

APPROXIMATE CELL LIMITS

10 FT. IN SITU LOW PERMEABILITY SOIL

10 FT. DOCUMENTED IN SITU LOW PERMEABILITY SOIL

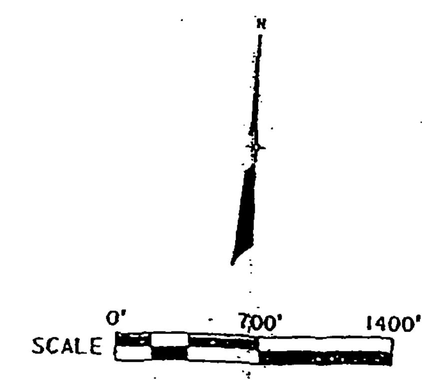
10 FT. COMPACTED LOW PERMEABILITY SOIL

COMPOSITE LINER (3 FT. COMPACTED LOW PERMEABILITY SOIL AND GEOMEMBRANE)

NOTES

1) DRAWING MODIFIED FROM FIGURE 1-3 (RUST JUNE, 1997)

2) REFER TO SECTION 5.0 LINER SYSTEM DESIGN (RUST JUNE, 1997) FOR DISCUSSION OF LINER SYSTEMS



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LINER CONFIGURATION LOCATIONS
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	MIB	03/27/2008
Checked:	GMB	03/27/2008
Approved:	CSR	03/27/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	2	

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SOUTH SIDE WELL-TW-1 GAS MIGRATION INVESTIGATION AREA
MALLARD LAKE LANDFILL
BFI WASTE SYSTEMS OF NORTH AMERICA
HANOVER PARK, ILLINOIS

Drawn:	EMP	02/07/2008
Checked:	CSR	02/08/2008
Approved:	CSR	02/08/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	FIG. 3	

EXISTING GAS PROBE LOCATION

CONE PENETROMETER TEST PROBE LOCATION

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PROBE GPE INVESTIGATION AREA
GAS MIGRATION NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
BFI WASTE SYSTEMS OF NORTH AMERICA
HANOVER PARK, ILLINOIS

Drawn :	EMP	02/07/2008
Checked:	CSR	02/08/2008
Approved:	CSR	02/08/2008

PROJECT NUMBER 200704805

FIGURE NUMBER FIG. 4

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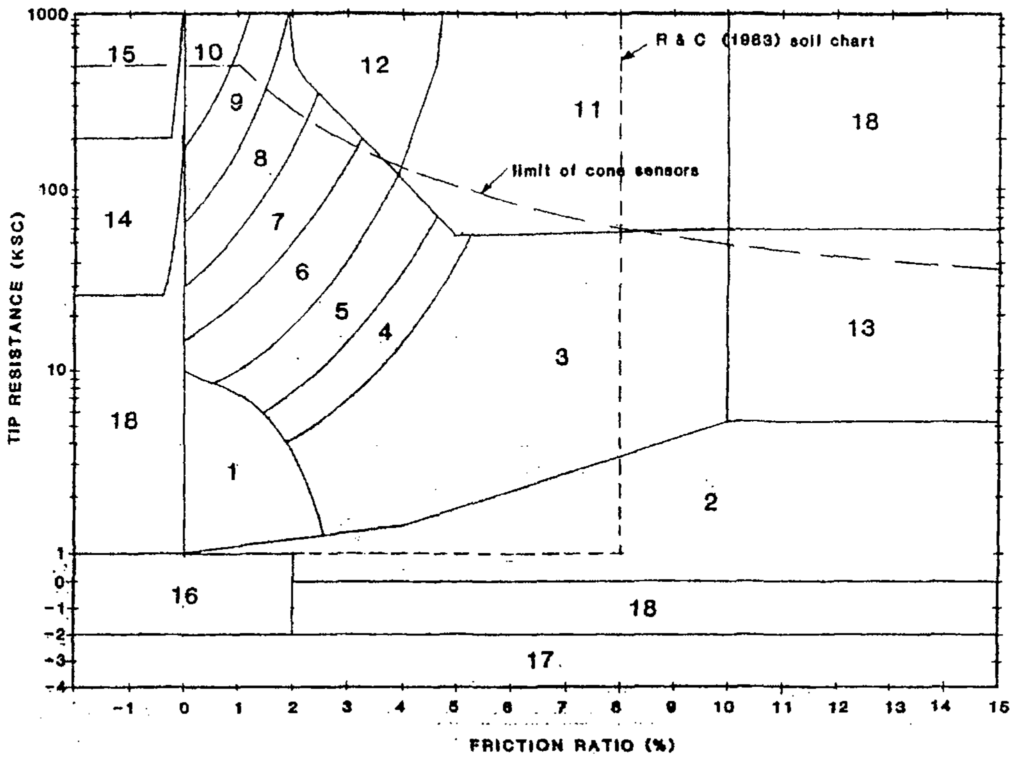

Zone Number	SPT qc/N	Soil Behavior Type: Printout Name	Soil Behavior Type: Plot Name
1	2	Sensitive fine grained	Sens. fines
2	1	Organic material	Organic
3	1	Clay	Clay
4	1.5	Silty clay to clay	Silty clay
5	2	Clayey silt to silty clay	Clayey silt
6	2.5	Sandy silt to clayey silt	Silt
7	3	Silty sand to sandy silt	Sandy silt
8	4	Sand to silty sand	Silty sand
9	5	Sand	Sand
10	6	Gravelly sand to sand	Grav. sand
11	1.6+	Very stiff fine grained*	Stiff fines*
12	2	Sand to clayey sand*	Clayey sand*
13+	1	Plastic clay	Plastic clay
14+	5	Cobble	Cobble
15+	6	Boulder	Boulder
16+	–	Void	Void
17+	–	-- No data --	No data
18+	–	-- No soil correlation --	No correl

CPT designations used to delineate W1/W2 unit

* over consolidated or cemented
\+ STS extension

Notes:

1) Original soil chart is from Robertson & Campanella (1983).
2) STS extensions to the R & C chart are based on extensive local experience with Midwestern soils.
3) Zone 17 "-- No data --" extends for all TIP values of -2 ksc and below.
4) All other areas not shown on the soil chart are Zone 18 "-- No soil correlation --".
5) Cone sensor limit corresponds to a maximum tip load of 500 ksc and a maximum friction load of 5 ksc.

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SOIL BEHAVIOR TYPES FROM CPT DATA
LANDFILL GAS MIGRATION NATURE
AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	M1B	03/26/2008
Checked:	GMB	03/26/2008
Approved:	CSR	03/26/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	5	

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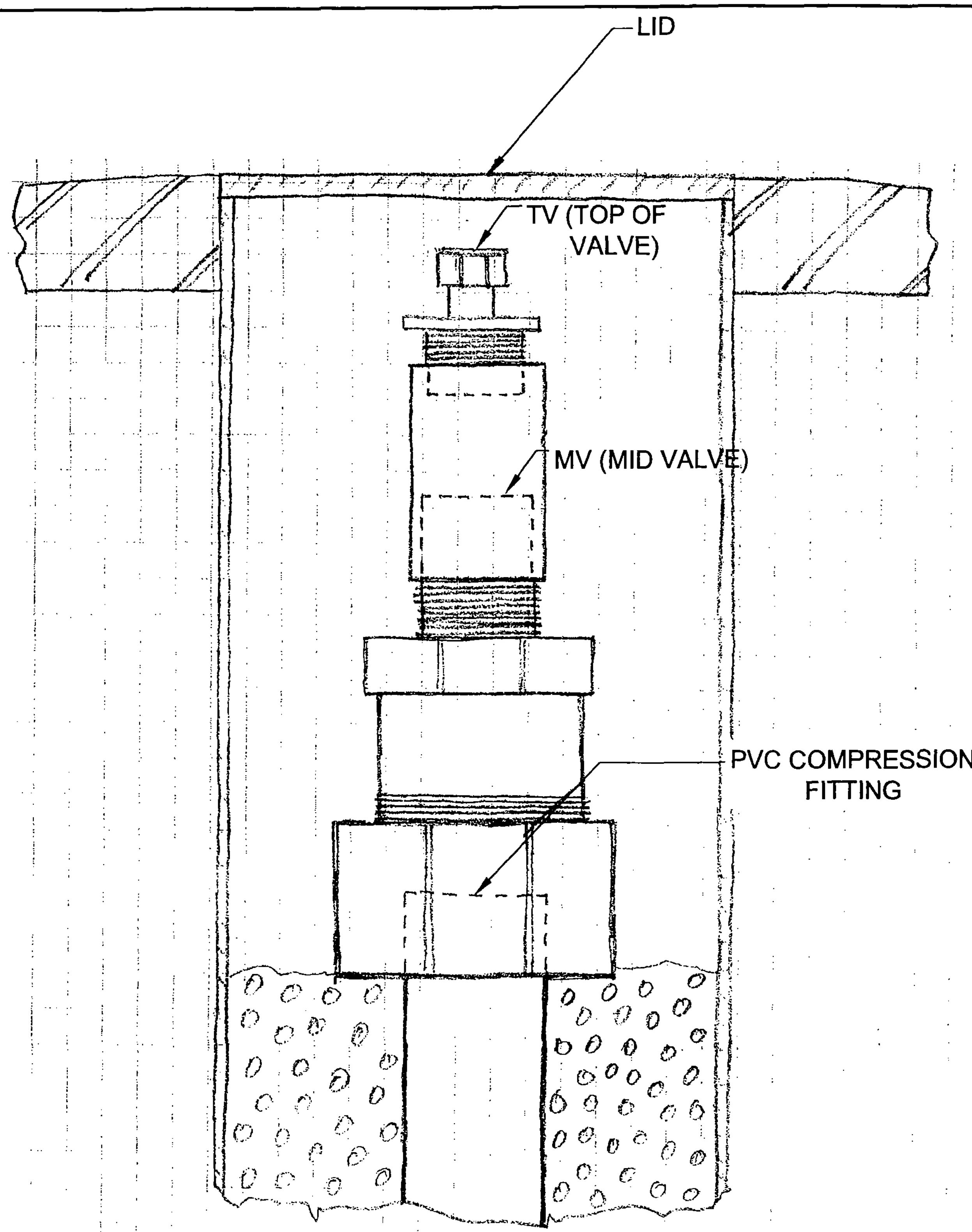

SKETCH PROVIDED BY:
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CPT GAS PROBE COMPLETION DETAIL
LANDFILL GAS MIGRATION NATURE
AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	M1B	03/26/2008
Checked:	GMB	03/26/2008
Approved:	CSR	03/26/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	6	

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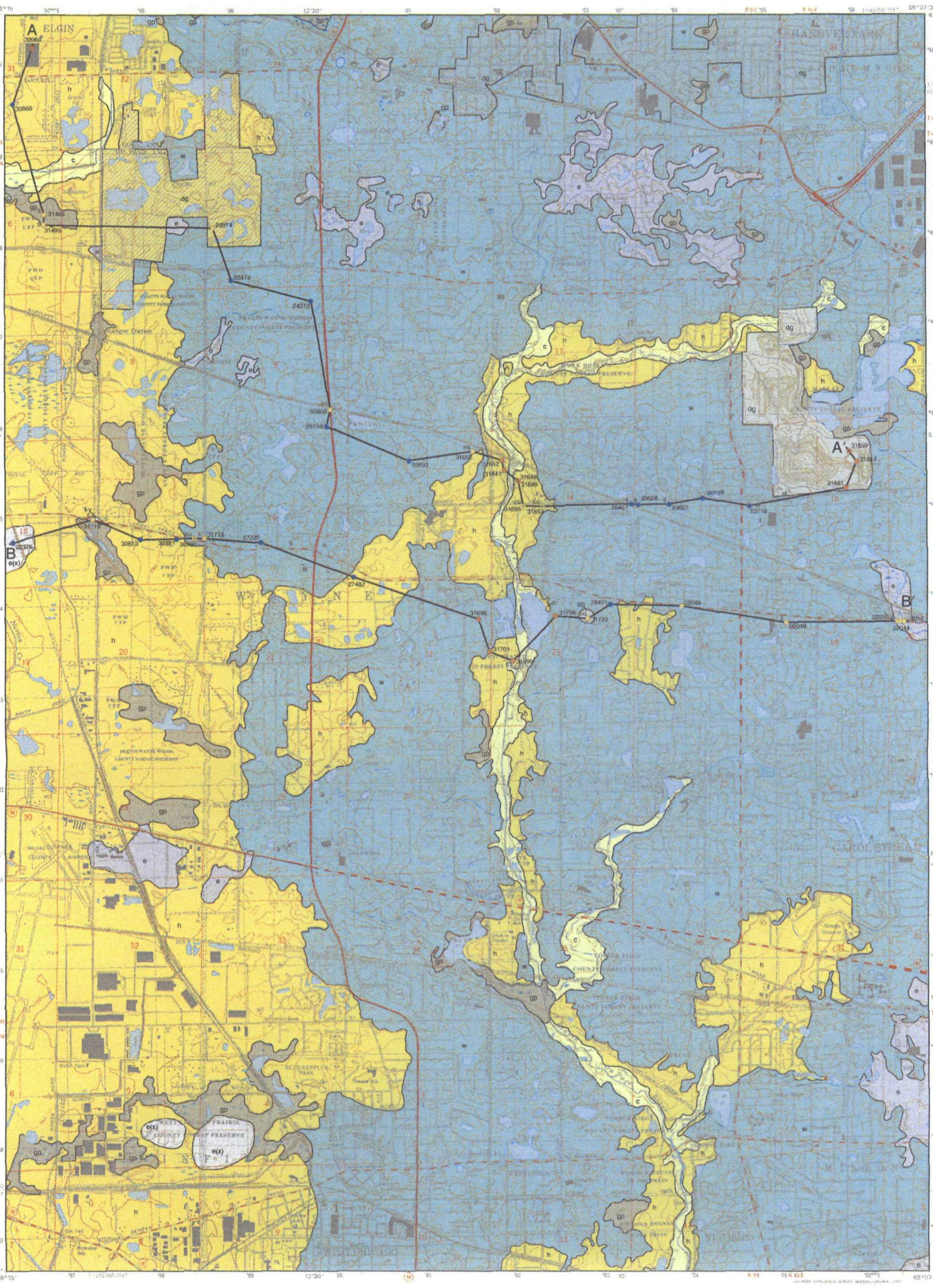
Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

SURFICIAL GEOLOGY OF WEST CHICAGO QUADRANGLE
COOK AND DUPAGE COUNTIES, ILLINOIS

STATEMAP West Chicago-SG

B. Brandon Curry
2007



QUATERNARY DEPOSITS

Description	Unit	Interpretation
HUDSON EPISODE (~14,700 years before present (B.P.) to today)		
Fill (disturbed earth material); primarily material reworked from underlying deposits	Disturbed ground (dg)	**Disturbed land;** embankments and mounds (gray); pits and quarries (diagonal lines)
Peat and muck; black and brown; interbedded sand and silty clay (gray) and marl (white to light gray); less than 15 feet thick in most places	Grayslake Peat (gp)	**Decomposed wetland vegetation and sediment** in depressions and on slopes
Sand and gravel; well-sorted sand and lenses of peat, grading laterally to organic-rich fossiliferous silt and clay; less than 10 feet thick in most places	Cahokia Formation (c)	**Floodplain alluvium** along rivers and streams
HUDSON EPISODE (~14,700 years B.P. to today) and WISCONSIN EPISODE (~29,000–14,700 years B.P.)		
Silt, clay, and fine sand; layered (laminated) to massive; gray to brown, fossiliferous in many places; no more than 15 feet thick in most places	Equality Formation (e)	**Lake deposits** in kettles and in valleys tributary to the West Branch DuPage River
WISCONSIN EPISODE (~29,000–14,700 years B.P.)		
Succession of laminated, fossiliferous **silt** (3 to 10 feet thick), and upper weathered **sand and gravel** (0 to 10 feet thick); as much as 15 feet total thickness	Equality Formation (complex) (e(x))	**Ice-walled lake deposits** forming low level terraces; formed of sorted sediment of the Mason Group, including sand and gravel of the Henry Formation and very fine sand, silt, and clay of the Equality Formation
Sand and gravel, or sand; lenses of silt and clay or diamicton; yellowish brown to brown; as much as 65 feet thick in northwestern part of map	Henry Formation (h)	**Channelized proglacial outwash** along valley of West Branch Du Page River; proglacial outwash deposited in deltas and alluvial fans as outwash plains downslope of West Chicago Moraine
Diamicton; silty clay and silty clay loam; loam and silt loam diamicton near base; gray, oxidizing to yellowish brown with interbeds of sand and gravel increasing in thickness and relative proportion (with respect to diamicton) towards the west; generally less than 40 feet thick west of the West Branch Du Page River, and as much as 120 feet thick east of the river	Wadsworth Formation (w)	**Till and debris flow deposits** associated with the West Chicago Moraine
Diamicton; sandy loam, loam, silt loam; dolomite-rich; yellowish brown to gray; as much as 15 feet thick	Haeger Member, Lemont Formation (cross sections only) (l-h)	**Till and debris flow deposits** associated with the West Chicago Moraine
Sand and gravel below the Haeger Member and Wadsworth Formation; the coarse facies is mostly stratified sand and gravel as much as 50 feet thick; the fine facies is laminated fine sand and silt as much as 65 feet thick	Beverly Tongue, Henry Formation (cross sections only) (h-b)	**Proglacial lake sediment and outwash** deposited in lakes, deltas, and alluvial fans
Diamicton; clay, silty clay, and silty clay loam, gray, oxidizing to yellowish brown; includes layers of sand and gravel, silt, and silty clay; as much as 70 feet thick	Yorkville Member, Lemont Formation (l-y)	**Till and debris flow deposits**
Diamicton; sandy loam to loam with abundant cobbles; gray to grayish brown, with layers of sand and gravel or silt and sorted sediment; as much as 75 feet thick	Batestown Member, Lemont Formation (cross sections only) (l-b)	**Till, debris flow, and outwash deposits**
Diamicton; clay loam to loam matrix (roughly equal amounts of sand, silt, and clay) with lenses of sand and gravel, or sand; reddish brown; as much as 25 feet thick	Tiskilwa Formation (cross sections only) (t)	**Till and debris flow deposits**
WISCONSIN EPISODE (~55,000–29,000 years B.P.)		
Silt and clay; organic-rich, black to brown; leached of carbonate minerals; contains wood fragments; less than 5 feet thick; described from only a few well records	Robein Member, Roxana Silt (cross sections only) (r-r)	**Accretionary paleosol; A-horizon of Farmdale Geosol; deposits accreted in low-lying areas**
ILLINOIS EPISODE (~200,000–130,000 years B.P.		
Sand and gravel; rarely encountered in subsurface	Pearl Formation (cross sections only) (pl)	**Outwash**

PRE-QUATERNARY DEPOSITS

Description	Unit	Interpretation (from Graese 1991)
SILURIAN SYSTEM (~440–410 million years B.P.)		
Dolomite; microcrystalline; white, light gray, and light greenish gray; cherty in places; thin beds of green shale (Kankakee and Joliet Formations) about 60 feet thick	Wilhelmi, Elwood, Kankakee, and Joliet Formations (cross sections only) (S)	Dolomitized carbonate bank deposits

Data Type

- Stratigraphic boring
- Water well boring
- Engineering boring

SG 26211 — **Labels indicate samples (s) or geophysical log (G).** **Boring** labels indicate the county number. **Dot indicates boring is to bedrock.**

Contact

A—A′ Line of cross section

Note: The county number is a portion of the 12-digit API number on file at the ISGS Geological Records Unit. Most well and boring records are available online from the ISGS Web site.

Base map compiled by Illinois State Geological Survey from digital data (Raster Feature Separates) provided by the United States Geological Survey. Topography compiled 1988. Planimitry derived from imagery taken 1998. Public Land Survey System and survey control current as of 1991. Boundaries current as of 2002.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, east zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

SCALE 1:24,000

1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
SUPPLEMENTARY CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2007

Geology based on field work by B. Curry in 1988, 2005, and 2006 and by B. Curry and N. Webb in 2007.

Digital cartography by J. Carrell, N. Webb, Z. Golshani, and J. Domier, Illinois State Geological Survey.

This research was supported in part by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under USGS award number 06HQAG0053. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

ISGS Illinois State Geological Survey

For more information contact:
Illinois State Geological Survey
615 East Peabody Drive
Champaign, Illinois 61820-6964
(217) 244-2414
http://www.isgs.uiuc.edu

1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Elgin
2 Streamwood
3 Palatine
4 Geneva
5 Lombard
6 Aurora North
7 Naperville
8 Wheaton

3°
APPROXIMATE MEAN DECLINATION, 2007

ROAD CLASSIFICATION

Primary highway, hard surface		Light-duty road, hard or improved surface	
Secondary highway, hard surface		Unimproved road	

U.S. Route — State Route

Figure 7
Surface Geology of The West Chicago Quadrangle
Landfill Gas Migration Nature and Extent Evaluation
Mallard Lake Landfill

GEOLOGIC TIME				GEOLOGIC UNITS		GEOTECHNICAL UNITS
SYSTEM	SERIES	STAGE	SUBSTAGE			
QUARTERNARY	HOLOCENE			CAHOKIA ALLUVIUM		A
QUARTERNARY	PLEISTOCENE	WISCONSINAN	WOODFORDIAN	WEDRON FORMATION	WADSWORTH TILL MEMBER	W-1 W-2 W-3 W-4
					LEMONT DRIFT (? Haeger Till Member)	L-1 L-2 L-3 L-4 L-5
UNCONFORMITY						Approx. 420 X 10^6 Years– No Record
SILURIAN	ALEXANDRIAN			DOLOMITE BEDROCK (UNDIFFERENTIATED)		BR

Cahokia Alluvium (Recent Alluvium) A		Silty clay, silt, and sand deposited in modern rivers, may contain organic debris (shells,wood,roots); characterized by high water contents (>25%), low unconfined compressive strengths (<1 TSF), and N values less than 15.
Wadsworth Till W	W1	Gray silty clay till, trace sand and gravel; water content 20-25%; generally no interbedded lenses or pockets of fluvial or lacustrine material. Upper part usually oxidized brown with water contents 15-20% and more dispersed sand and gravel in the till matrix--gradational contact to unoxidized gray W1.
		W1/W2 interface--gray silty sand, clayey sand and gravel, clayey silt: diamicton, fluvial, lacustrine material. Highly variable but almost always present; maximum thickness 15 ft. This material occasionally overlies W3 where W2 has been removed. Tentatively interpreted as melt-out deposit due to lateral persistence, variable lithology, and lack of evidence for glacial retreat and re-advance at this stratigraphic position.
	W2	Gray silty clay till, little sand and gravel; water content 15-20%; may contain pockets and discontinuous lenses of fluvial or lacustrine material.
	W3	Gray clayey silt to sandy silt till, little to some sand and gravel; water content 10-15%; may contain pockets and discontinuous lenses of sand, gravel, and silt that are locally thick.
	W4	Gray silty clay till, little to some sand and gravel; water content 15-20%; may contain pockets and discontinuous lenses of fluvial and lacustrine material.
Lemont Drift N>40 except when silty clay lacustrine materials are present in L1 and L4.	L1	Fluvial sand and gravel, silty sand; lacustrine silt/clayey silt-- Lemont outwash or proglacial Wadsworth.
	L2	Gray sandy silt diamicton, some gravel; water content <15%; generally >20% sand and gravel; lodgment till or melt-out till or sediment flow.
	L3	Gray sand and gravel, coarsening upward; top of proglacial Lemont sequence (fluvial).
	L4	Gray silt, silty clay, fine sand; generally massive;bottom of proglacial Lemont sequence (lacustrine).
	L5	Gray angular dolomite fragments with sand and gravel; bedrock rubble.
Silurian Dolomite Bedrock (undifferentiated) BR		Bedrock surface; refusal on split spoon sampler.

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DESCRIPTION OF GEOTECHNICAL UNITS (FROM BOGNER, 1988)
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	M1B	03/27/2008
Checked:	GMB	03/27/2008
Approved:	CSR	03/27/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	8	

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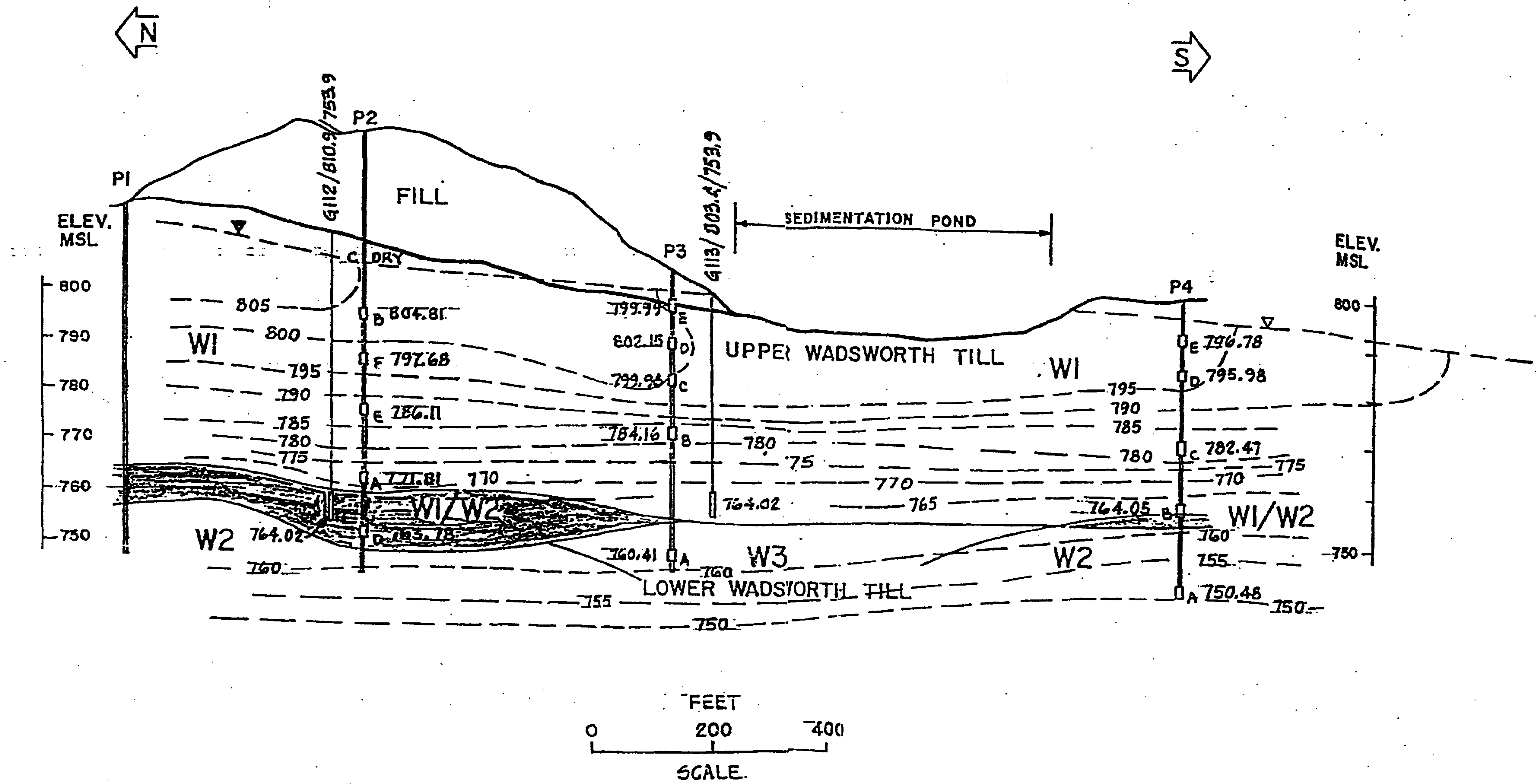

NOTES:

1. GEOLOGIC CROSS SECTIONS PROVIDED BY BOGNER (1988)
2. REFER TO APPENDIX C AND E (RUST JUNE 1997) FOR SOIL BORING LOG AND WELL CONSTRUCTION DETAILS.
3. POTENTIOMETRIC CONTOURS ADDED BY C. MOORE (1987)

D 795.98
C 782.47 — NESTED PIEZOMETER LOCATIONS ON PIEZOMETRIC HEAD LEVELS

— 770 — CONTOUR OF POTENTIOMETRIC HEAD

W1/W2 — INDICATED INTERGLACIAL SEDIMENTS (SILT, SILTY SAND, SAND ETC.)

APPROXIM
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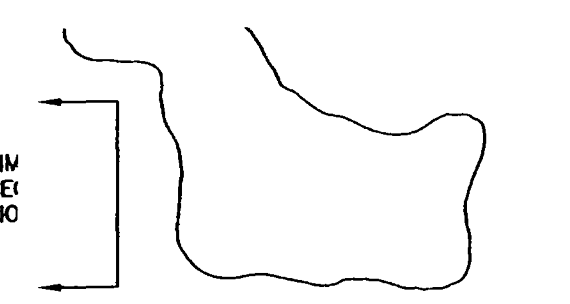

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POTENTIOMETRIC CROSS-SECTION ALONG WEST SIDE OF LANDFILL
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	MIB	03/26/2008
Checked:	GMB	03/26/2008
Approved:	CSR	03/26/2008
PROJECT NUMBER	200704805	
FIGURE NUMBER	9	

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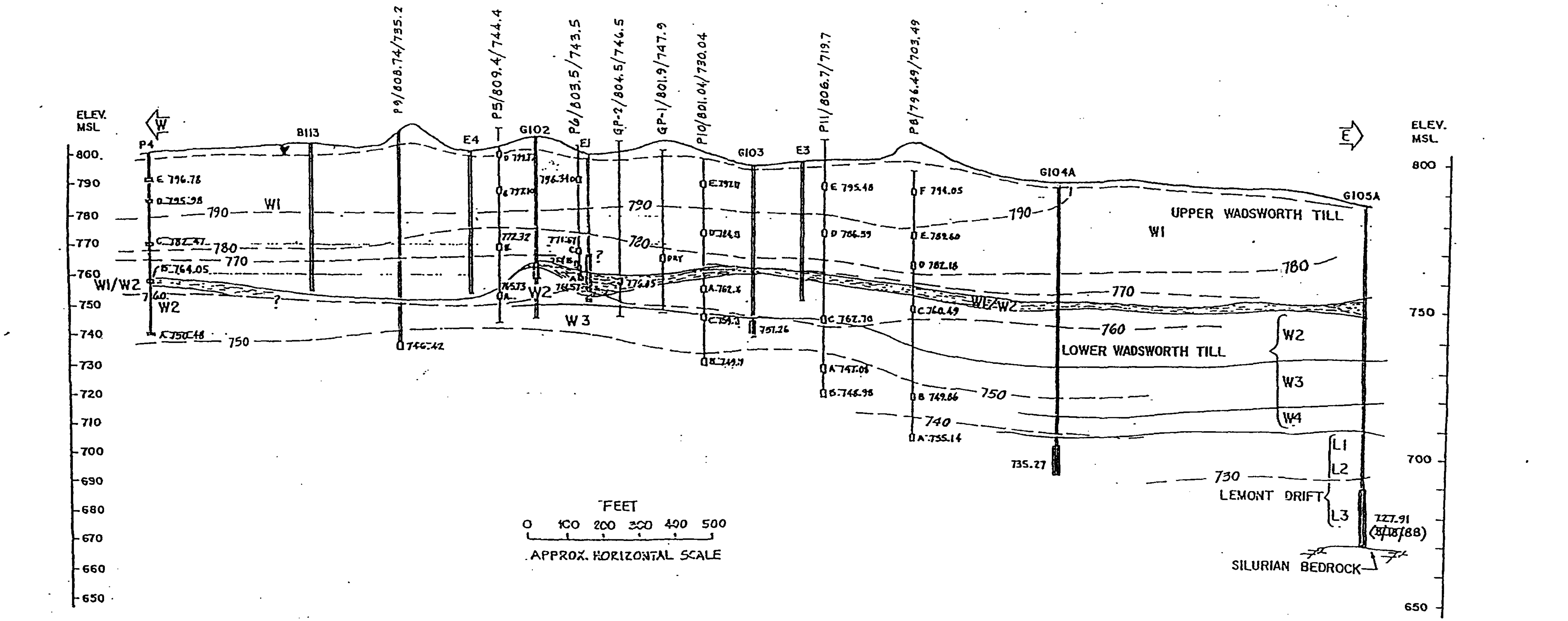


NOTES:

1. GEOLOGIC CROSS SECTIONS PROVIDED BY BOGNER (1988)
2. REFER TO APPENDIX C AND E (RUST JUNE 1997) FOR SOIL BORING LOG AND WELL CONSTRUCTION DETAILS.
3. POTENTIOMETRIC CONTOURS ADDED BY C. MOORE (1987)

LEGEND

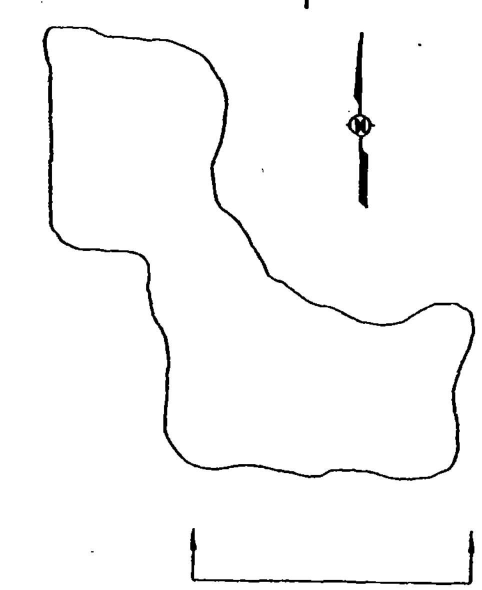
P4

E 796.78
D 795.98
C 782.47

NESTED PIEZOMETER LOCATIONS ON PIEZOMETRIC HEAD LEVELS

— 770 — CONTOUR OF POTENTIOMETRIC HEAD

W1/W2 INDICATED INTERGLACIAL SEDIMENTS (SILT, SILTY SAND, SAND ETC.)



APPROXIMATE CROSS-SECTION LOCATION

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POTENTIOMETRIC CROSS-SECTION E-W
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Drawn:	MIB 03/26/2008
Checked:	GMB 03/26/2008
Approved:	CSR 03/26/2008
PROJECT NUMBER	200704805
FIGURE NUMBER	10

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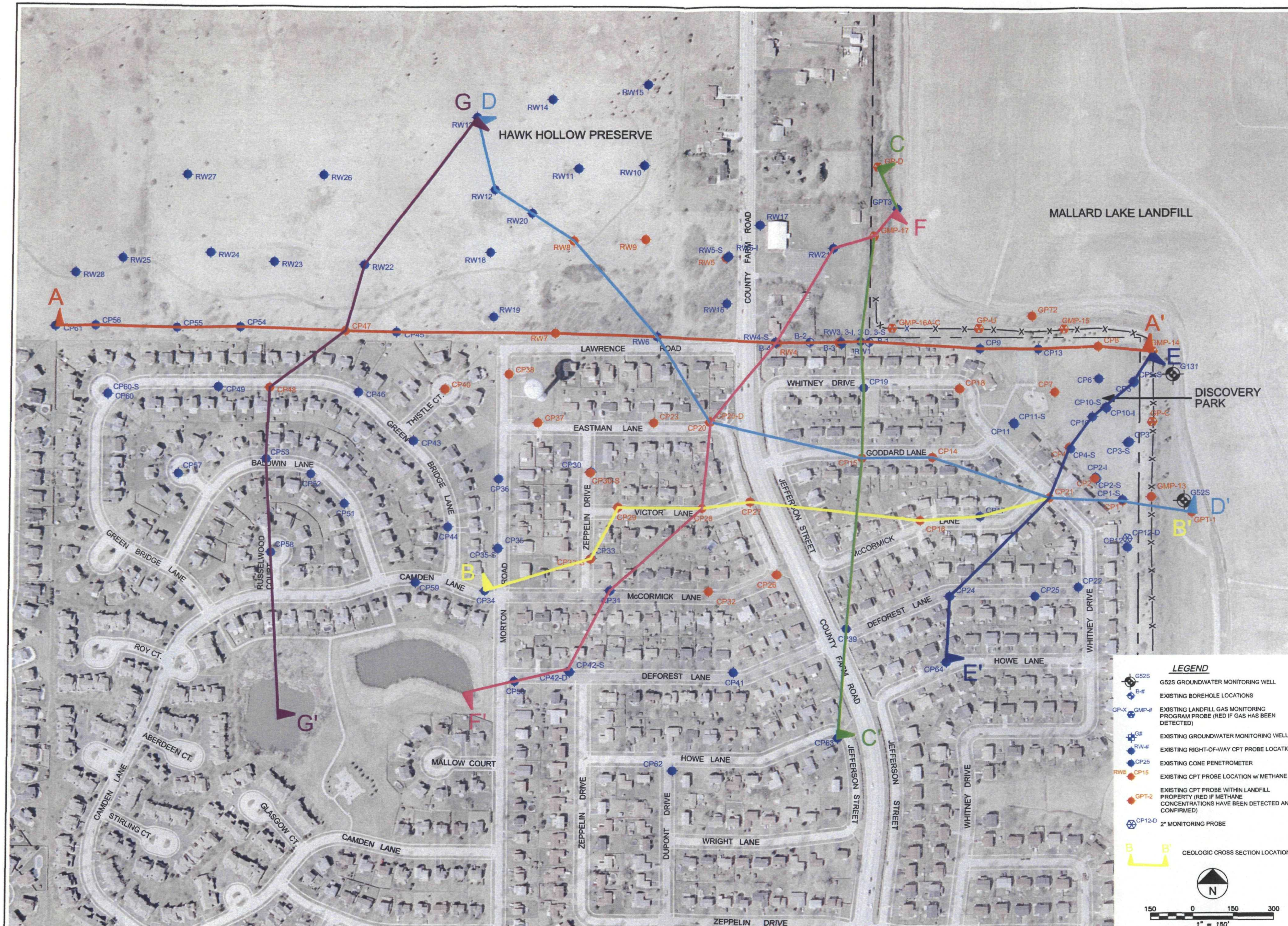

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GEOLOGIC CROSS SECTION LOCATION MAP
WEST SIDE INVESTIGATION AREA
LANDFILL GAS MIGRATION NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

Issued

Rev Date Description

Designed:	CSR	2/26/2008
Drawn:	EMP	2/27/2008
Checked:	MDW	2/28/2008
Approved:	CSR	2/28/2008

PROJECT NUMBER
200704807

SHEET REFERENCE NUMBER

FIG. 11

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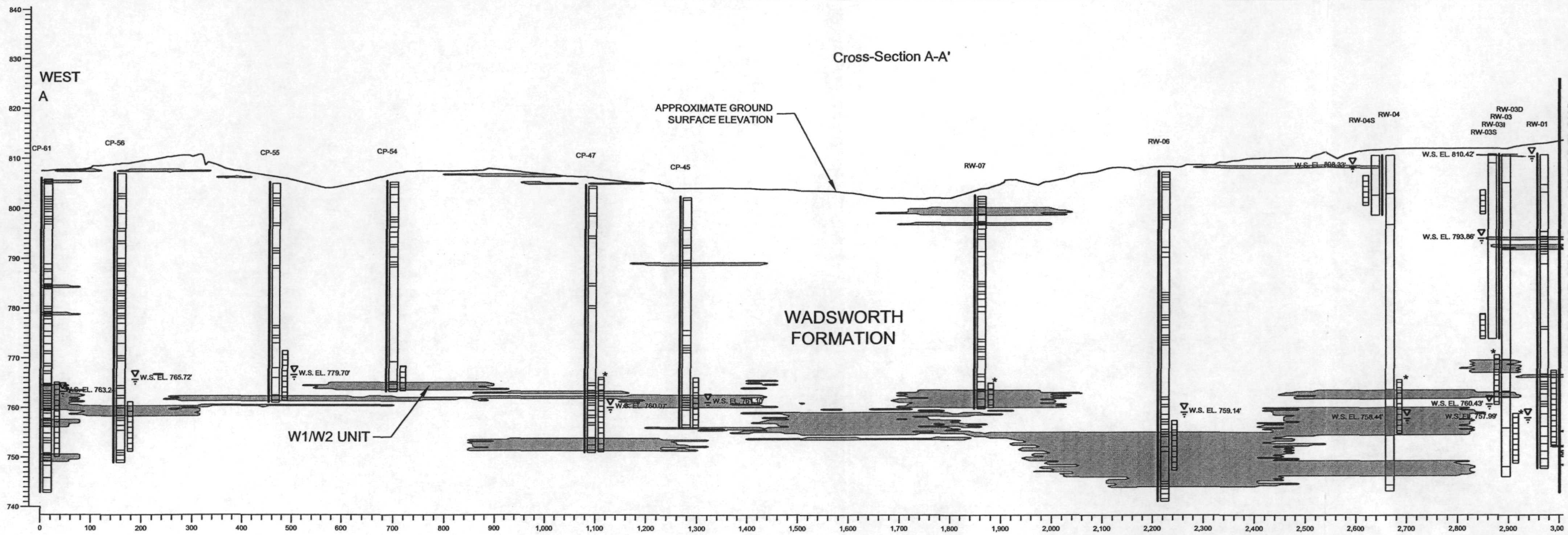

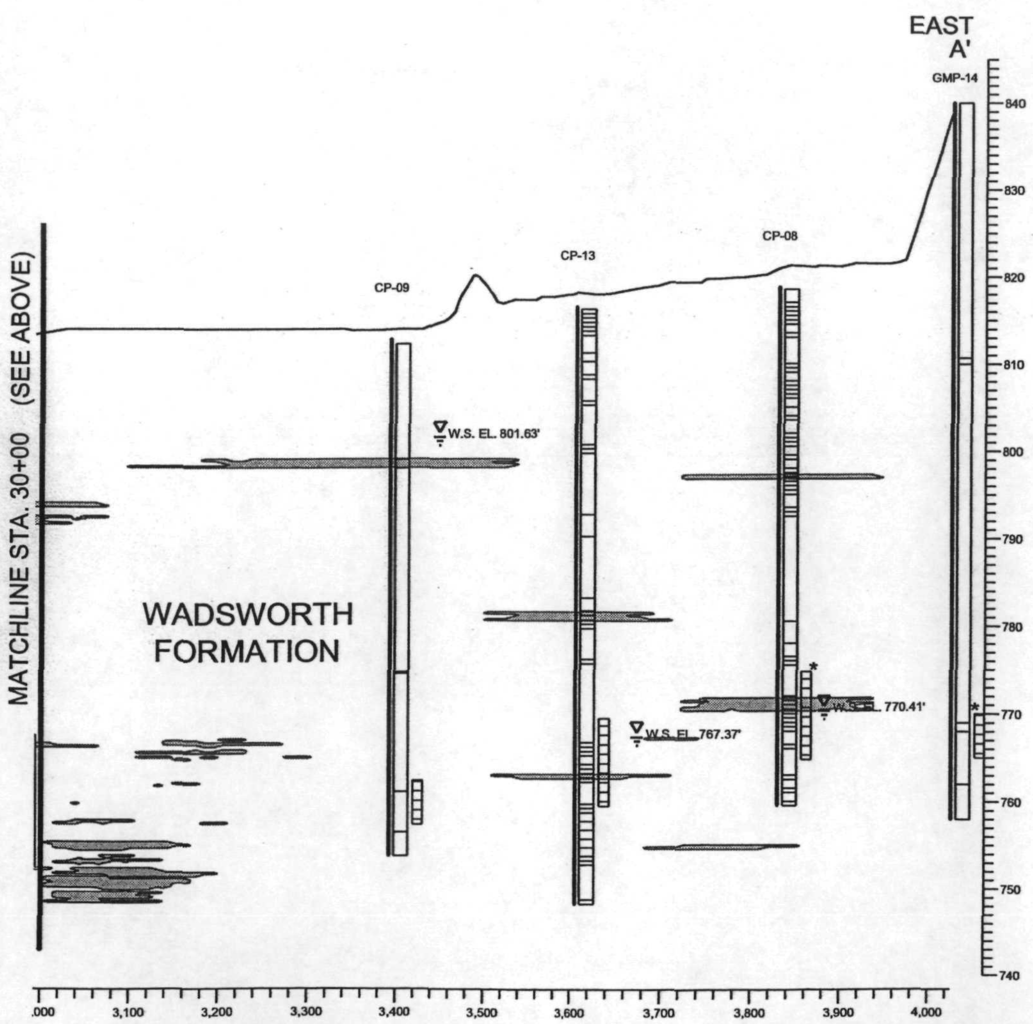

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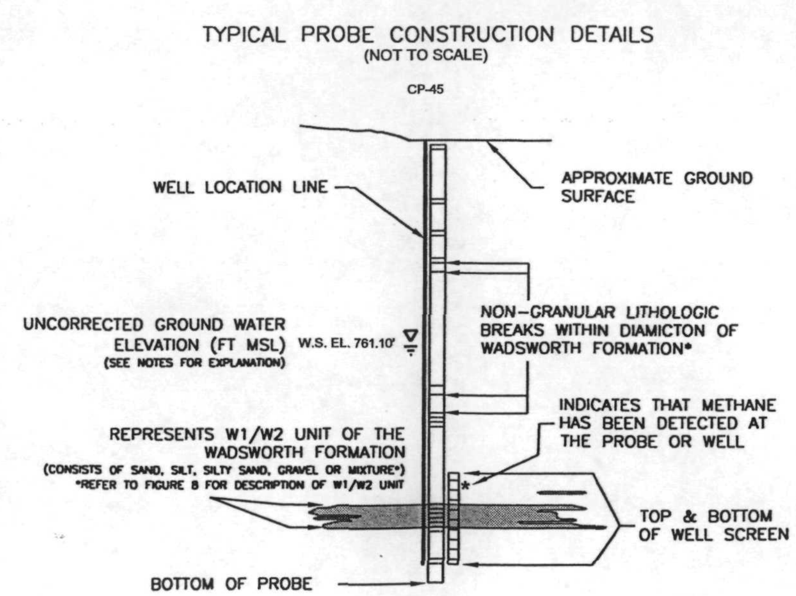

NOTES:

1) SURVEYING CONDUCTED BY WEAVER BOOS FEB–MAR., 2008. HORIZONTAL LOCATIONS HAVE BEEN REFERENCE TO BOTH SITE DATUM AND ILLINOIS STATE PLANE EAST (REFER TO TABLE 1). VERTICAL ELEVATIONS BASED ON USGS MEAN SEA LEVEL DATUM.

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4) THE GEOLOGIC CROSS–SECTIONS WERE CUT AT THE PROBE LOCATION LINE AS INDICATED IN THE LEGEND. DETAILS HAVE BEEN OFFSET FOR CLARITY.

5) REFER TO APPENDIX A FOR ALL GEOLOGICAL DATA

6) REFER TO APPENDIX B FOR WELL COMPLETION INFORMATION

7) REFER TO APPENDIX C FOR WATER LEVEL MONITORING DATA

8) REFER TO APPENDIX D FOR LANDFILL GAS MONITORING DATA

9) REFER TO TABLE 7 FOR GROUNDWATER QUALITY MONITORING DATA AND TABLE 6 FOR SUMMA CANISTER MONITORING RESULTS.

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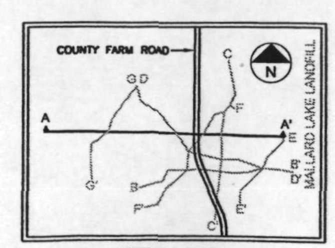
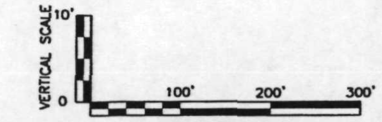


KEY MAP



HORIZONTAL SCALE
VERTICAL EXAGGERATION = 10X
NOTE: Scale equals 1"=10' Vertical and 1"=100' Horizontal when plotted on 24"x36" sheet.

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LANDFILL GAS MIGRATION
NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA

SECTION A-A'

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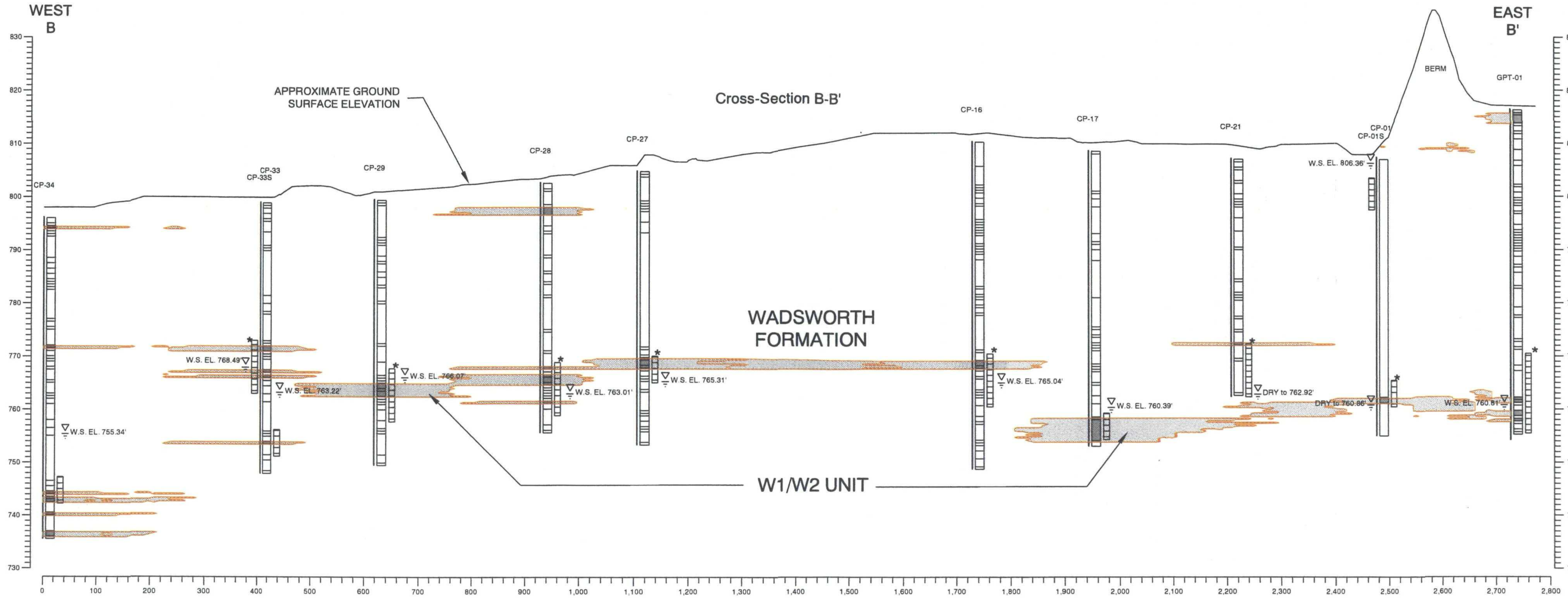
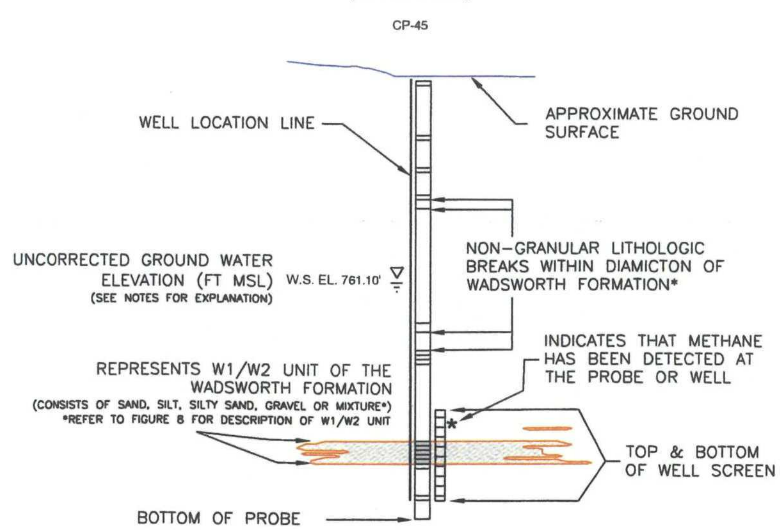
SHEET REFERENCE NUMBER
FIG.12



LEGEND:



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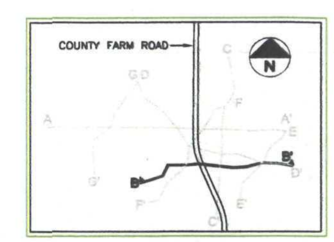
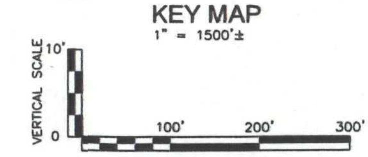


KEY MAP
1" = 1500'±



HORIZONTAL SCALE
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NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA

SECTION B-B'

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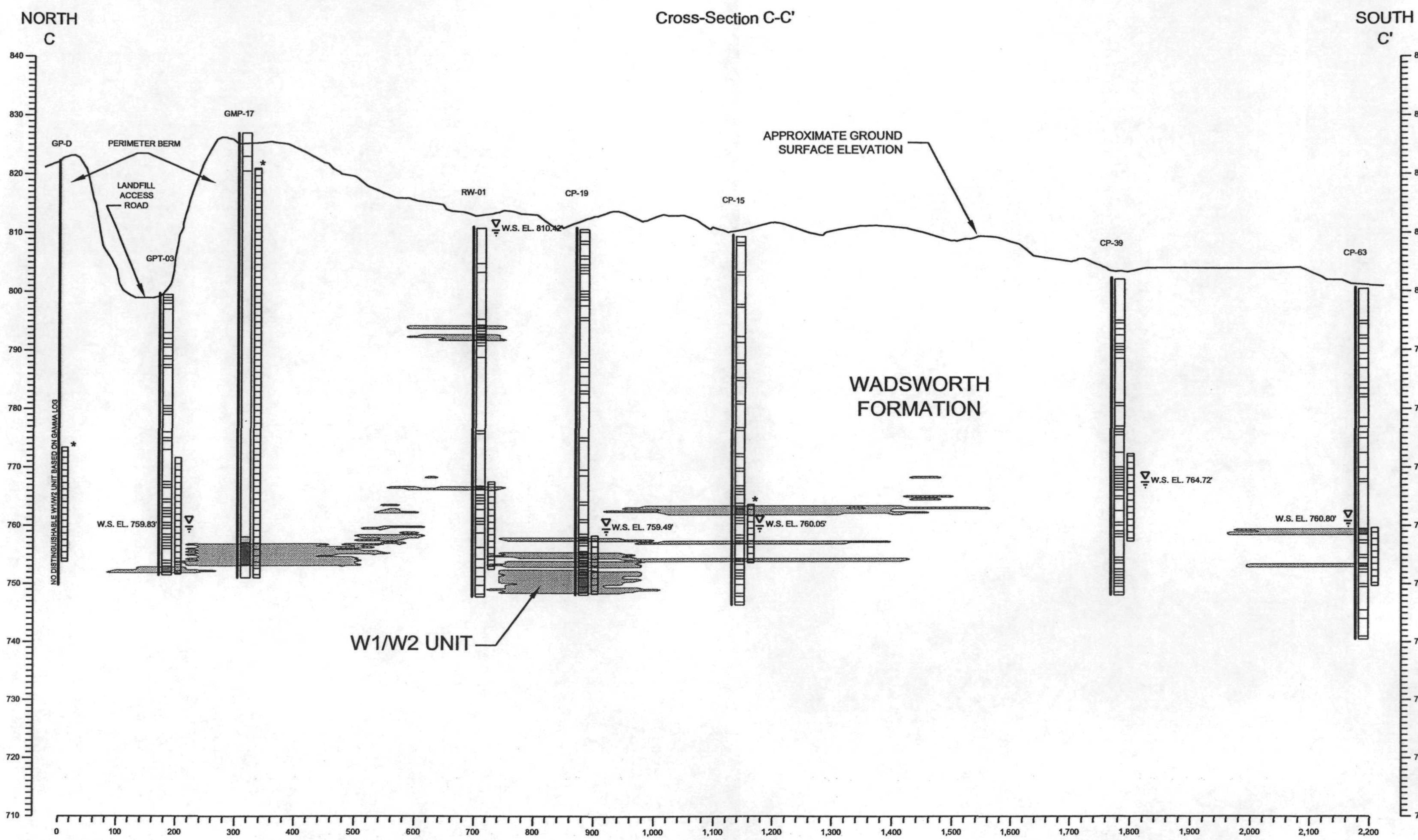
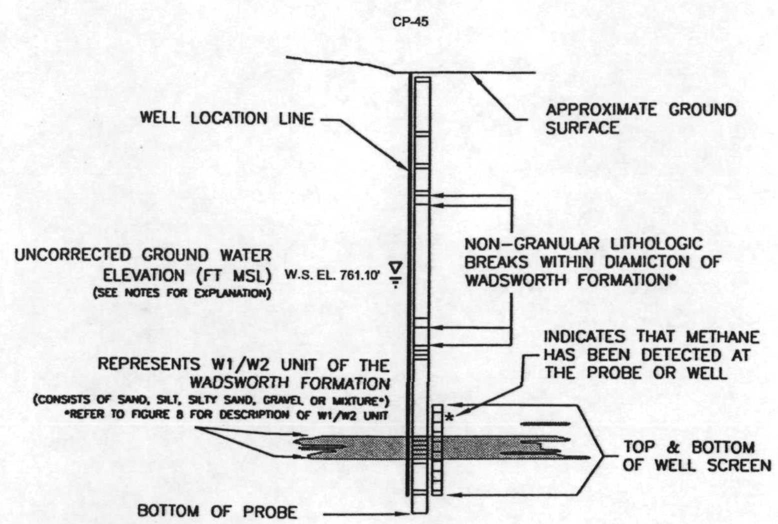
SHEET REFERENCE NUMBER
FIG. 13



LEGEND:

TYPICAL PROBE CONSTRUCTION DETAILS
(NOT TO SCALE)



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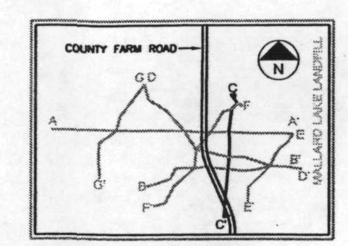
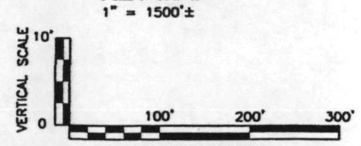


KEY MAP
1" = 1500'±



HORIZONTAL SCALE
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NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA

SECTION C-C'

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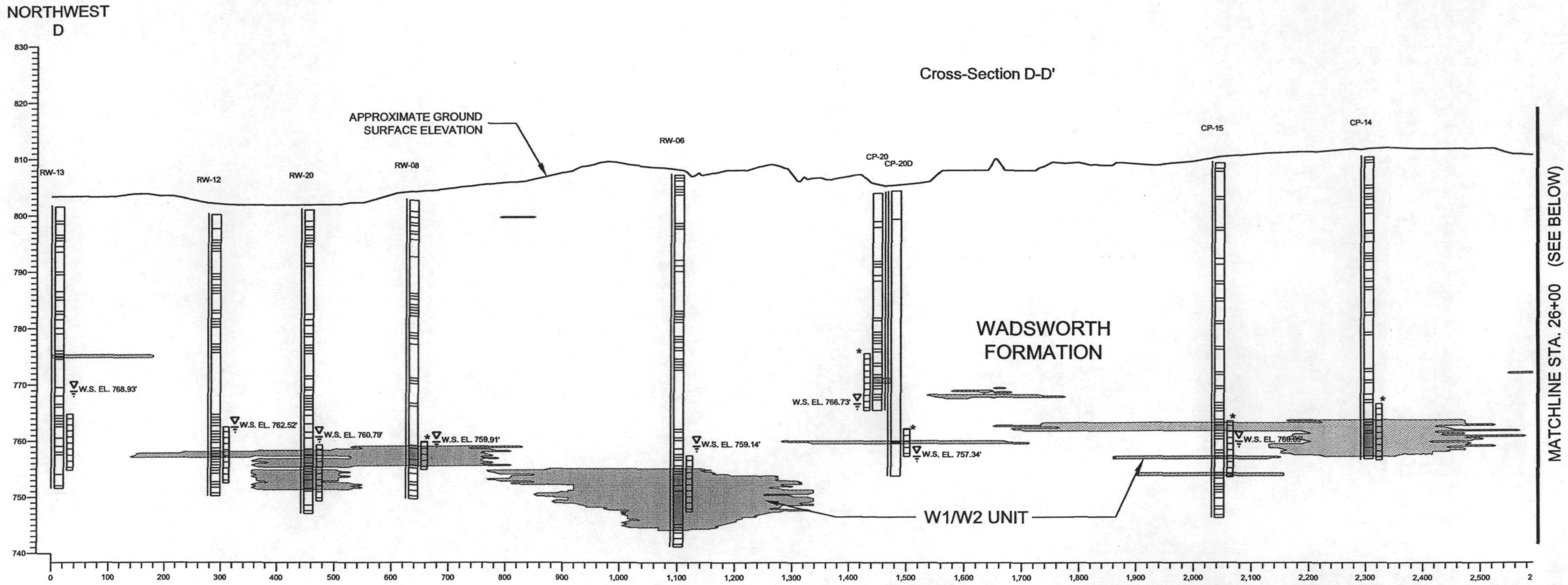
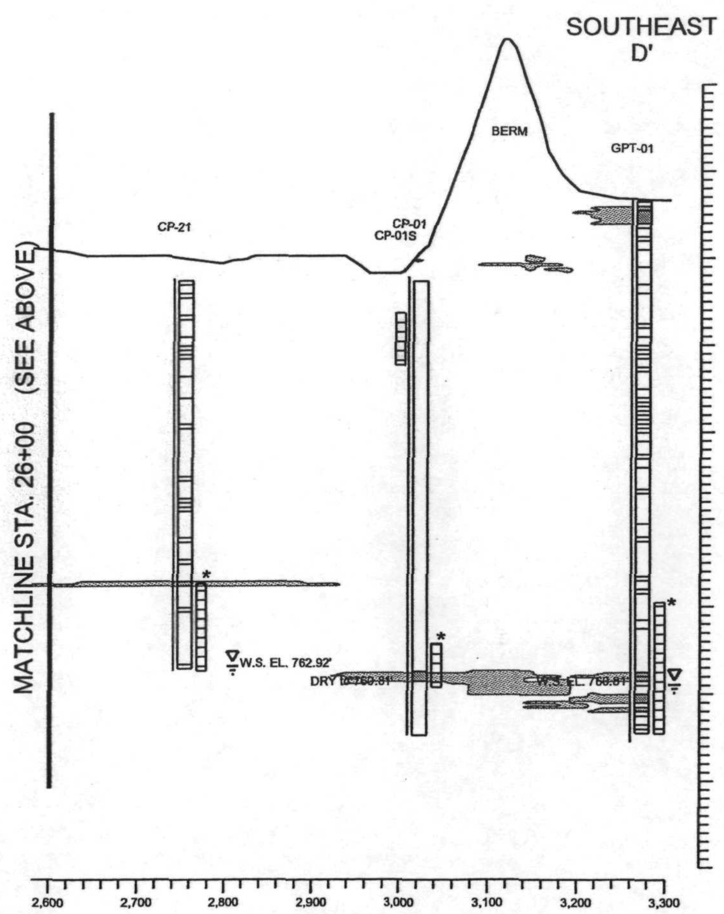
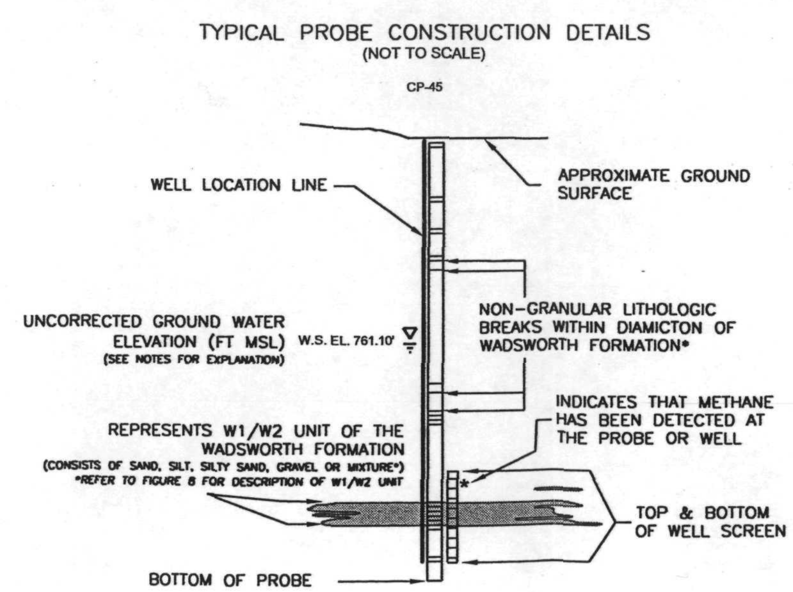
SHEET REFERENCE NUMBER
FIG.14





LEGEND:



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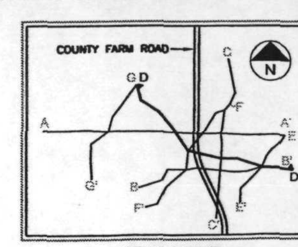
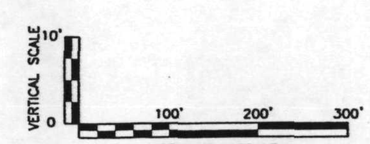


KEY MAP
1" = 1500'±



HORIZONTAL SCALE
VERTICAL EXAGGERATION = 10X
NOTE: Scale equals 1"=10' Vertical and 1"=100' Horizontal when plotted on 24"x36" sheet.

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LANDFILL GAS INVESTIGATION
NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA

SECTION D-D'

Issued

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PROJECT NUMBER
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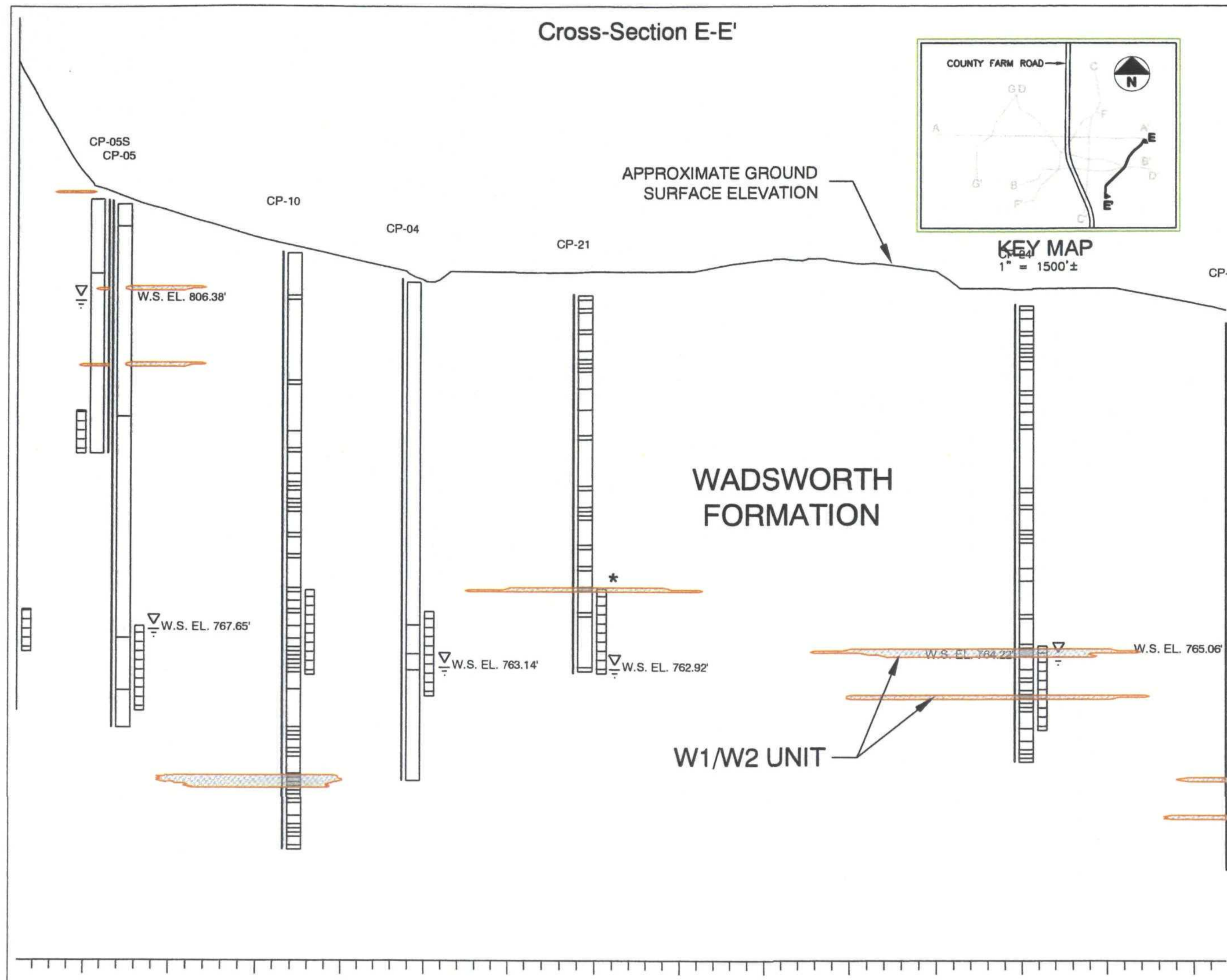
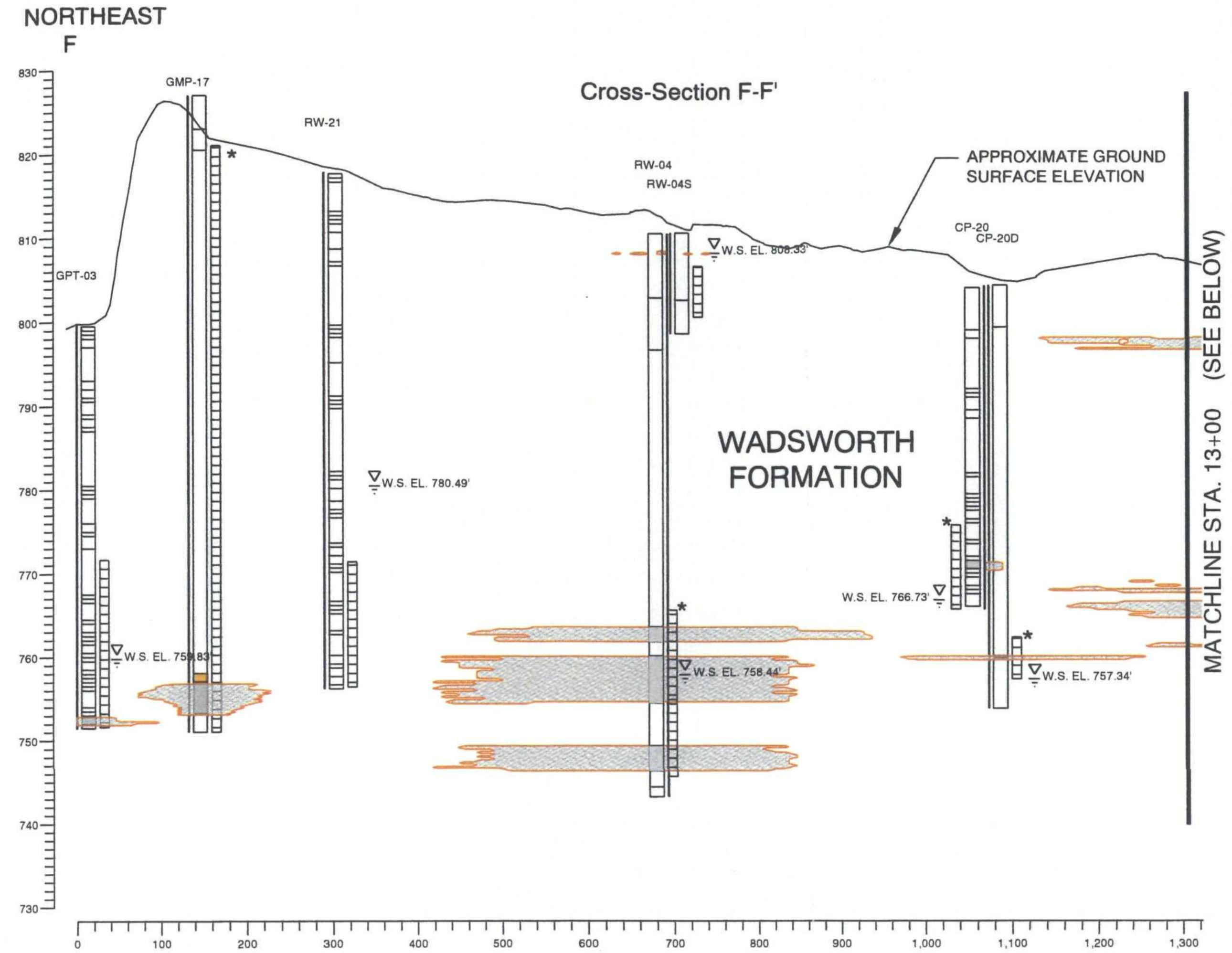
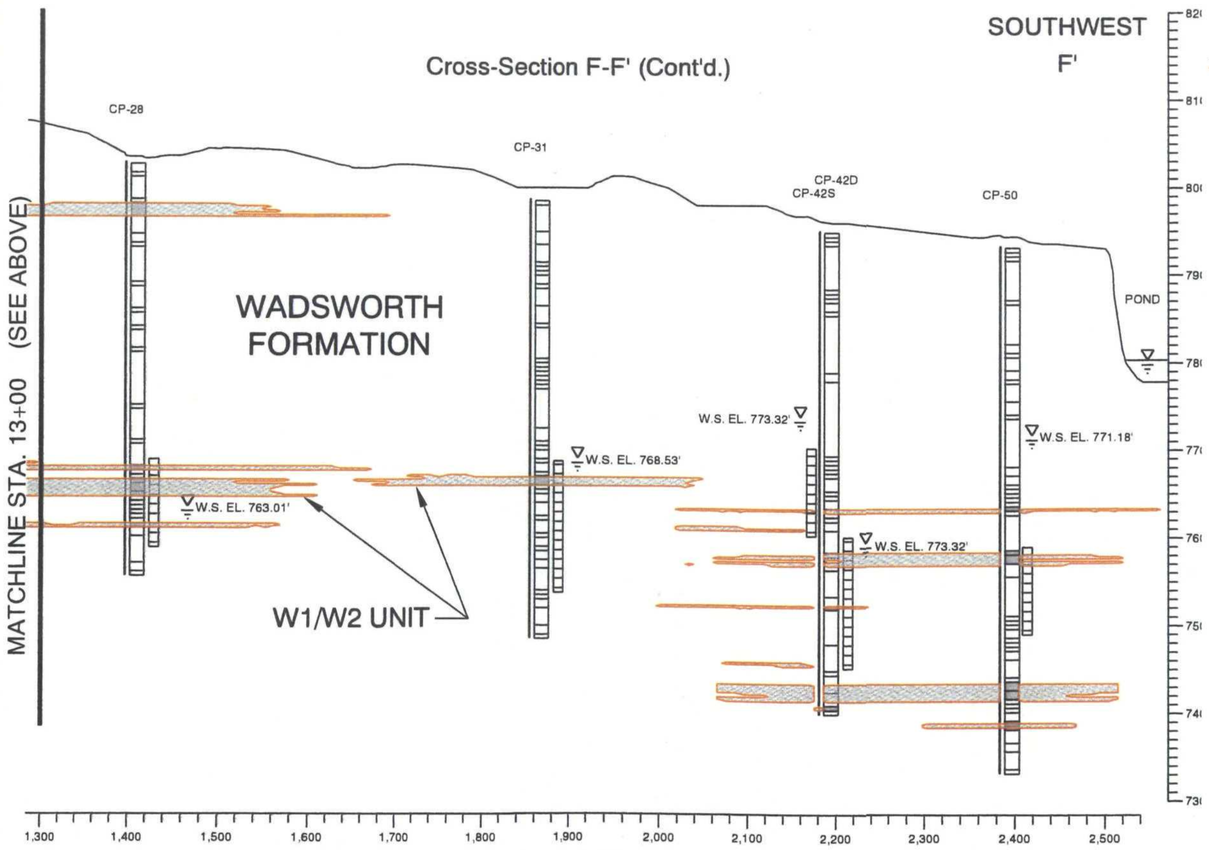
SHEET REFERENCE NUMBER

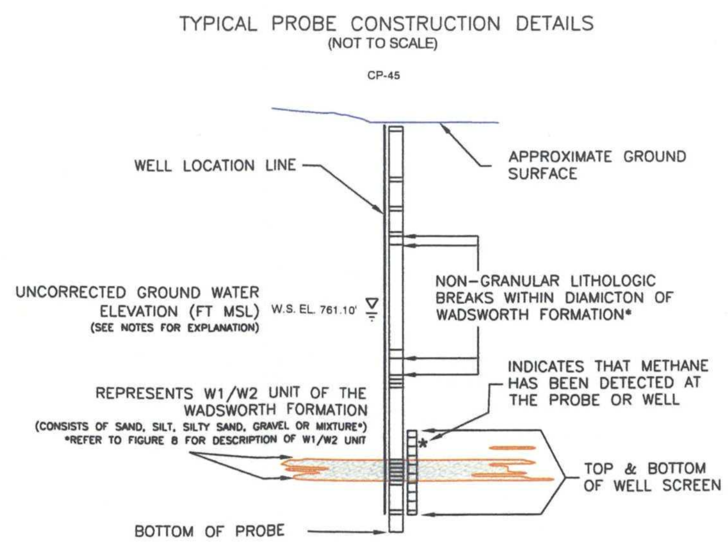
FIG. 15







LEGEND:



NOTES:

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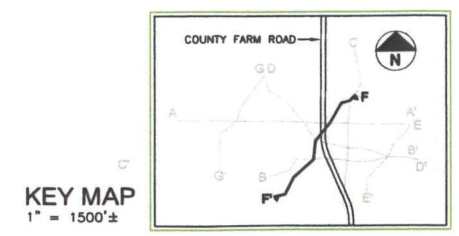

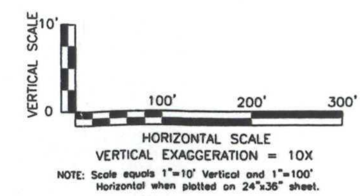

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LANDFILL GAS MIGRATION
NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA
SECTION E-E' & F-F'

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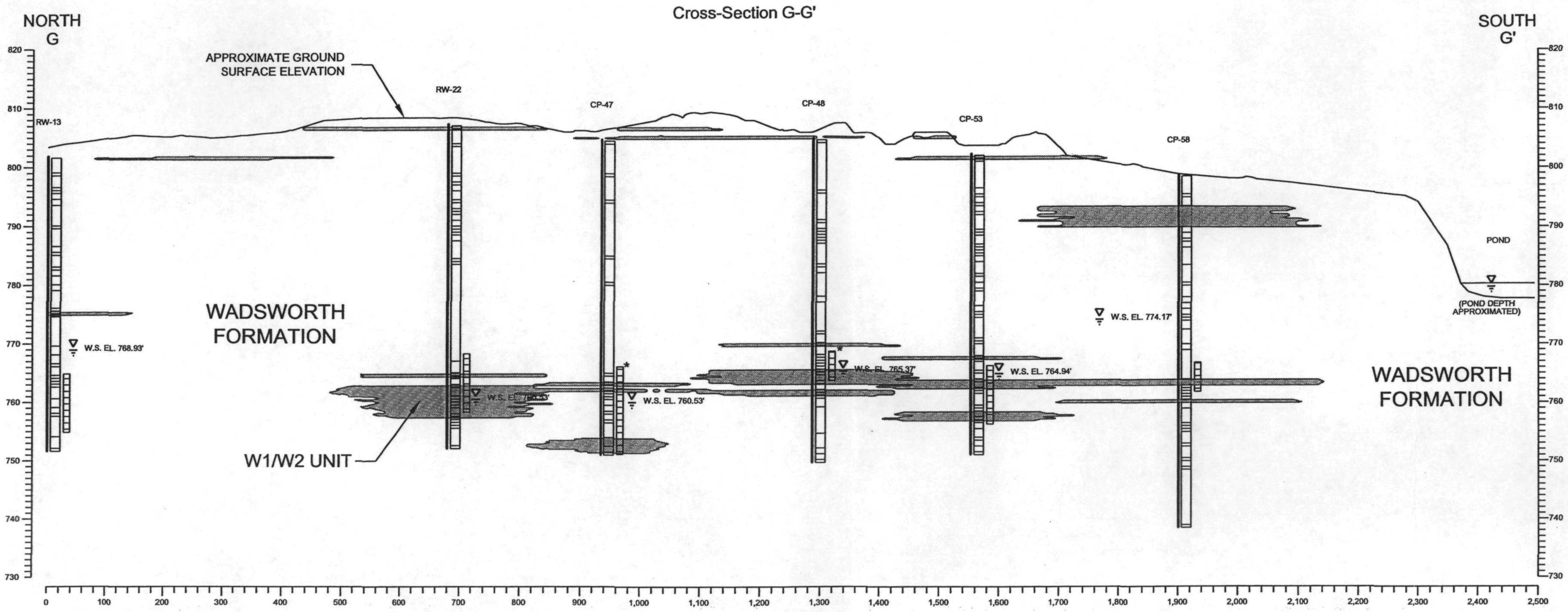
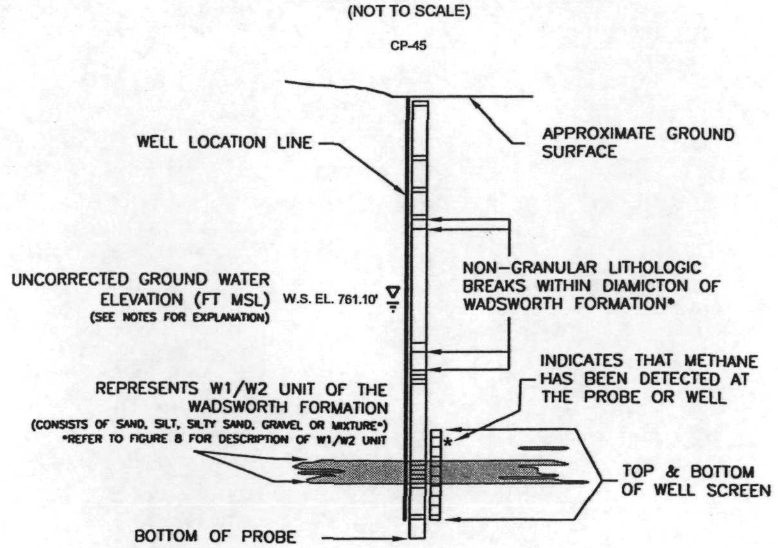
SHEET REFERENCE NUMBER

FIG.16



LEGEND:

TYPICAL PROBE CONSTRUCTION DETAILS
(NOT TO SCALE)



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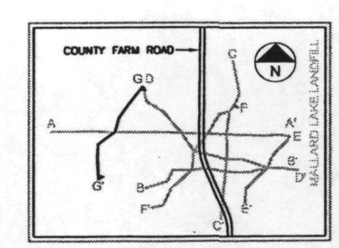
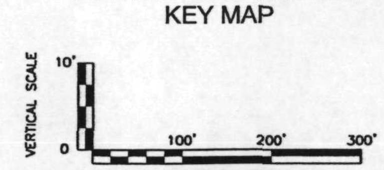


KEY MAP



HORIZONTAL SCALE
VERTICAL EXAGGERATION = 10X
NOTE: Scale equals 1"=10' Vertical and 1"=100' Horizontal when plotted on 24"x36" sheet.

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LANDFILL GAS MIGRATION
NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
WEST SIDE INVESTIGATION AREA
CROSS SECTION G-G'

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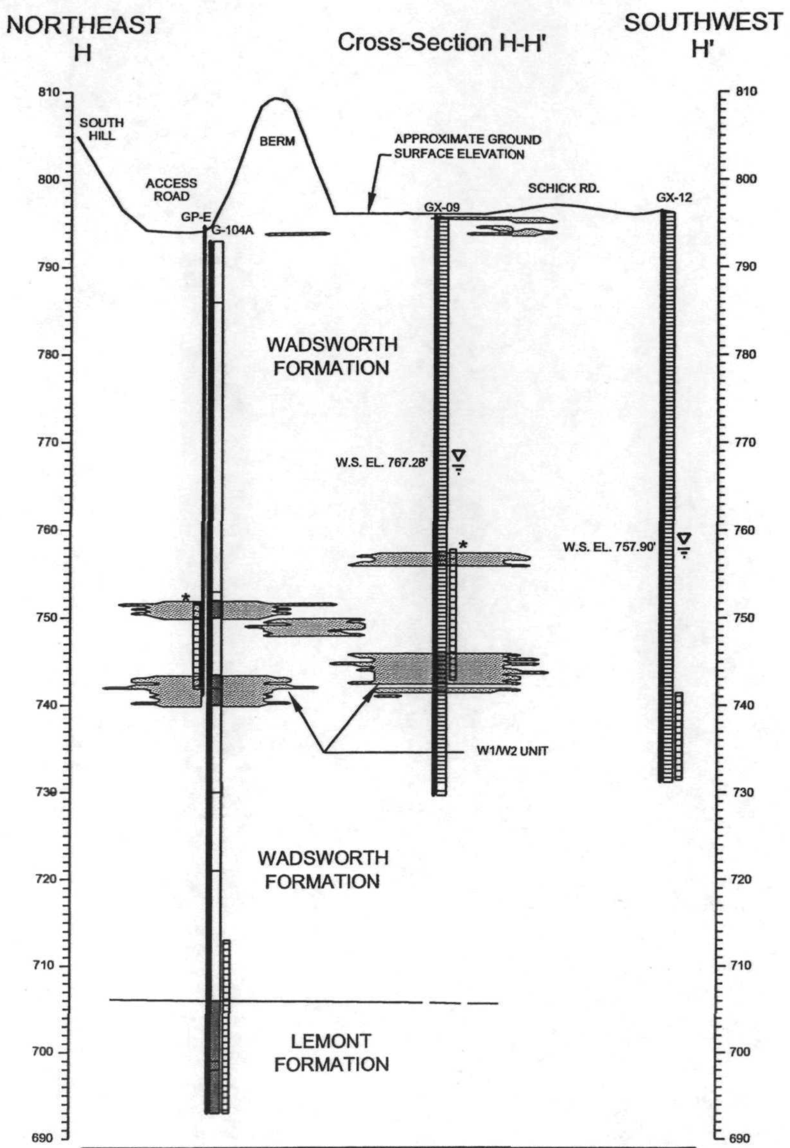
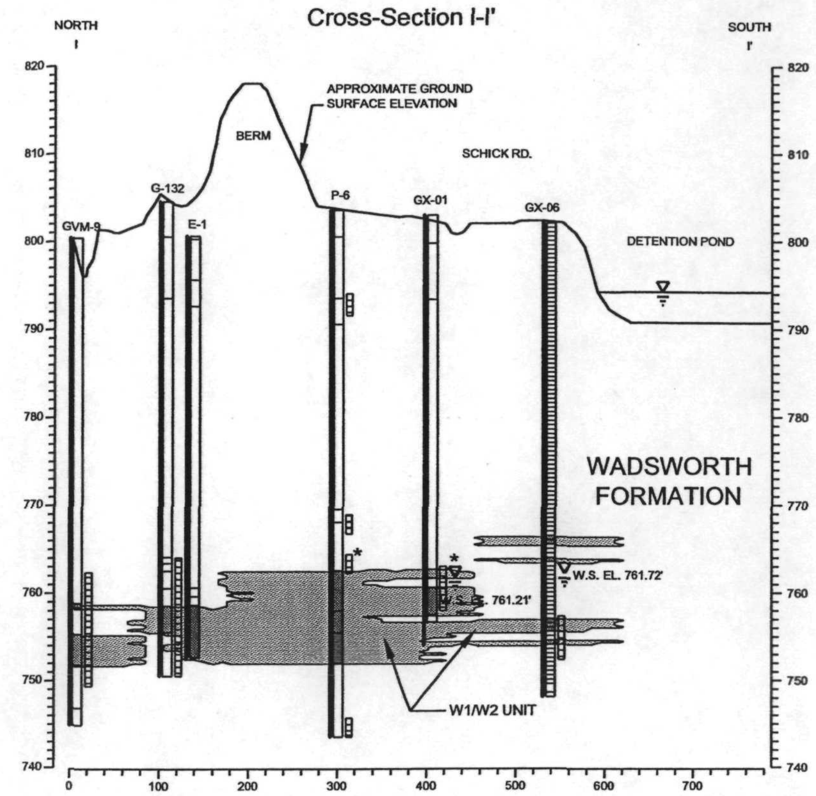
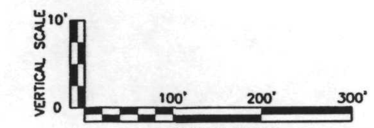
SHEET REFERENCE NUMBER
FIG.17





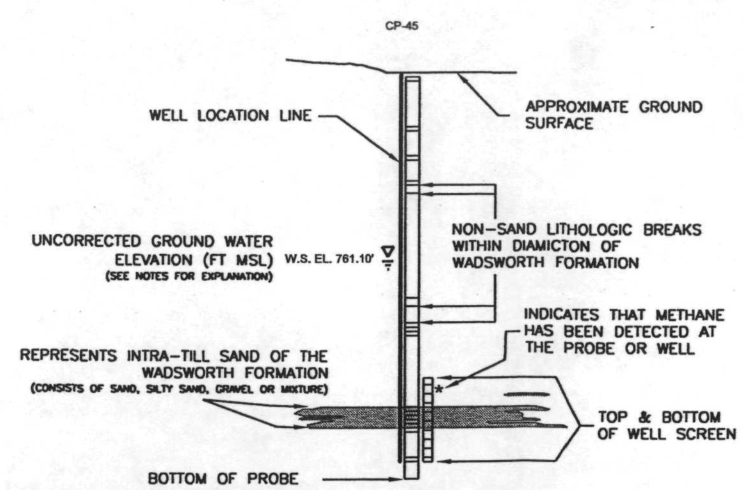


VERTICAL EXAGGERATION = 10X

NOTE: Scale equals 1"=10' Vertical and 1"=100' Horizontal when plotted on 24"x36" sheet.

LEGEND:

WELL CONSTRUCTION DETAILS



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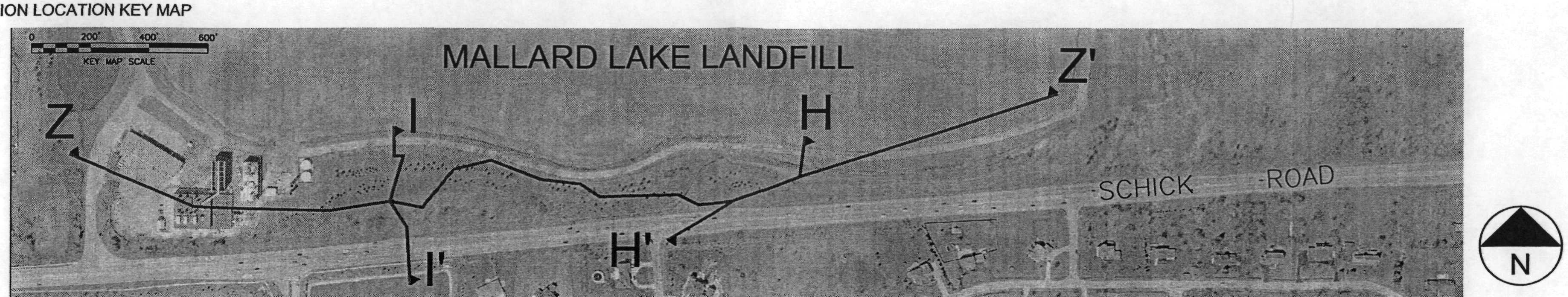
SOUTH SIDE INVESTIGATION
CROSS-SECTION LOCATION KEY MAP



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LANDFILL GAS MIGRATION
NATURE AND EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

GEOLOGIC CROSS SECTION
SOUTH SIDE INVESTIGATION AREA

SECTION H-H' AND I-I'

Issued

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200704805

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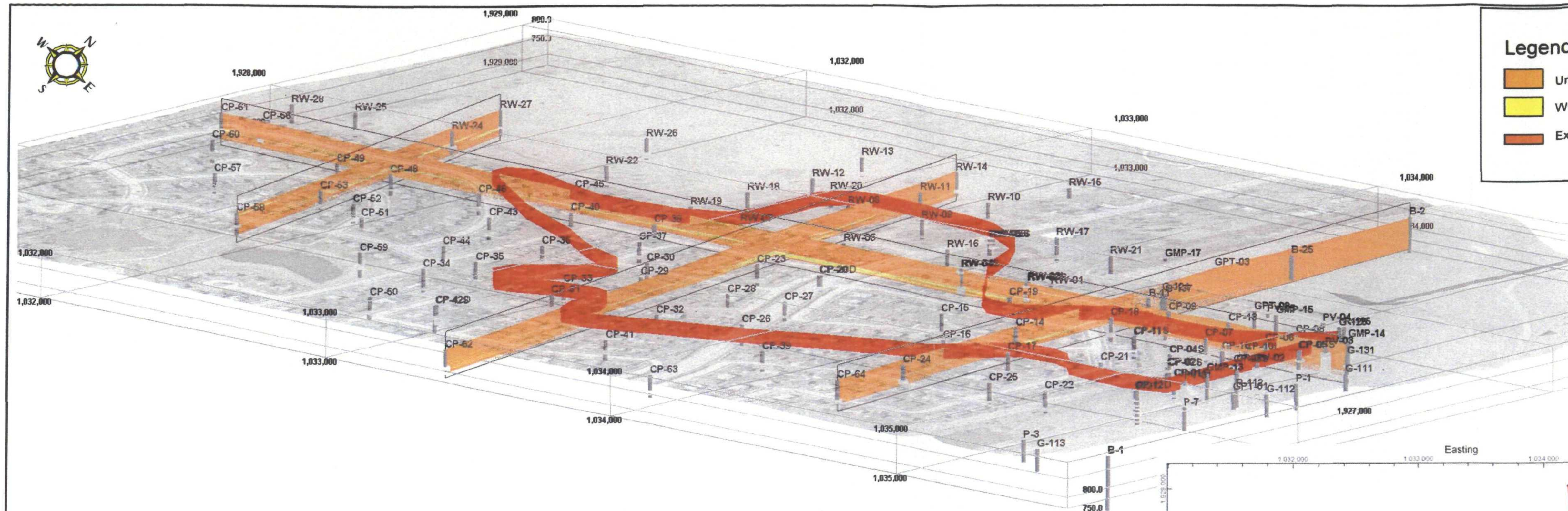
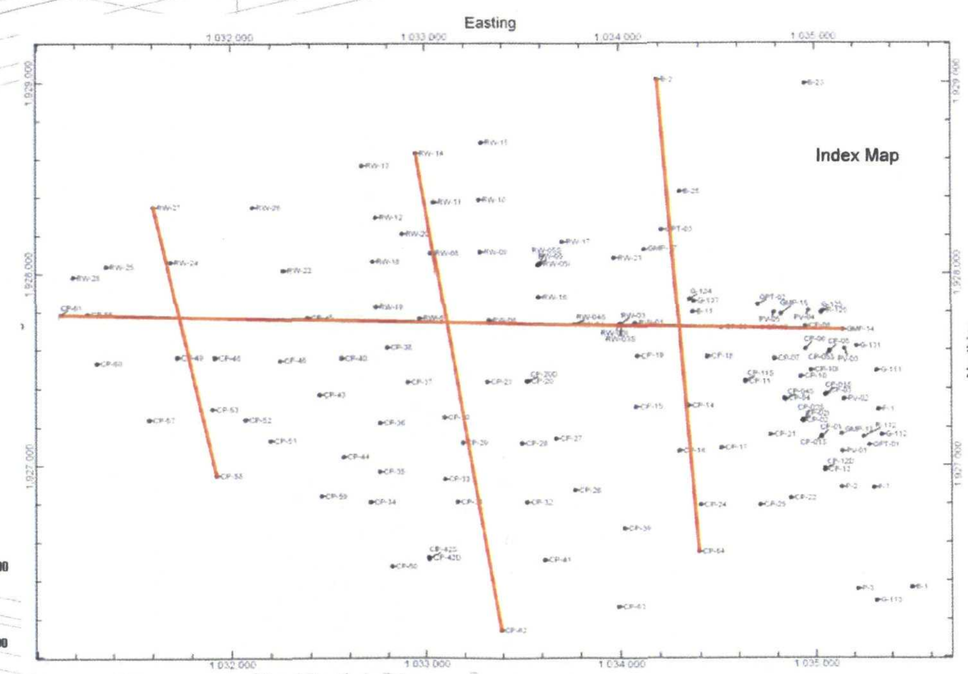
FIG.18

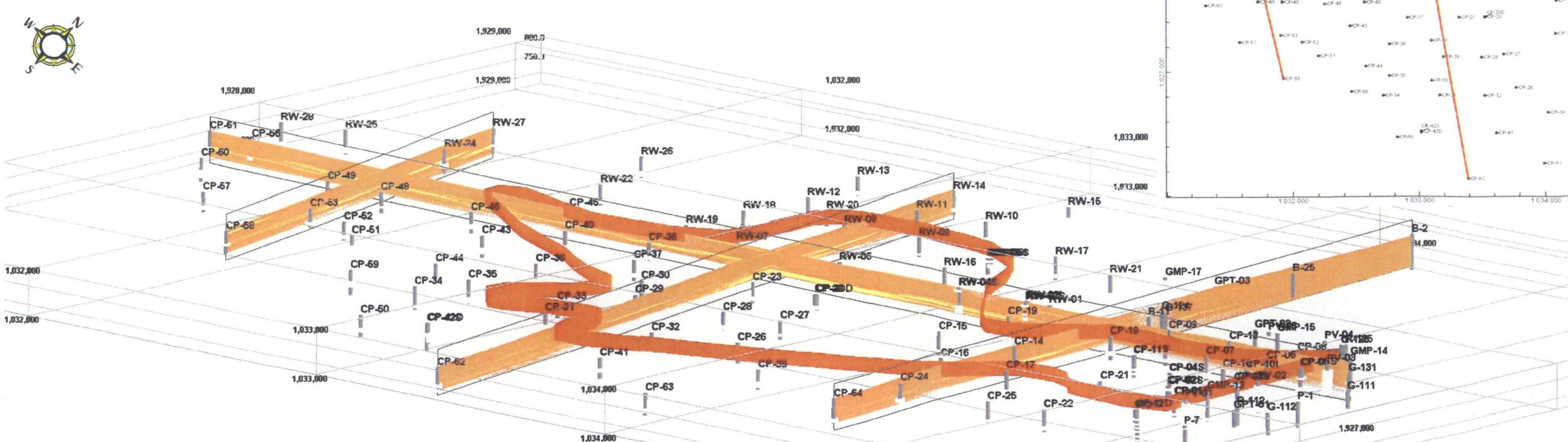
X:\PROJECTS\200704805\DWG\Cross Sections\SOUTH\Lith_sec_H-H'_&_I-I'.dwg; 4/3/2008 1:47:07 PM; DREW, PAUL; STS.stb



Legend

- Undifferentiated Wadsworth Diamicton
- W1/W2 Unit
- Extent of landfill gas





Notes: This information is for reference only. Geologic correlations are based on subsurface data obtained at soil boring and CPT probe locations. Actual subsurface conditions at any particular locations may vary

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Geologic Fence Diagram West Side
Landfill Gas Migration Nature and Extent Evaluation
Mallard Lake Landfill
Hanover Park, Illinois

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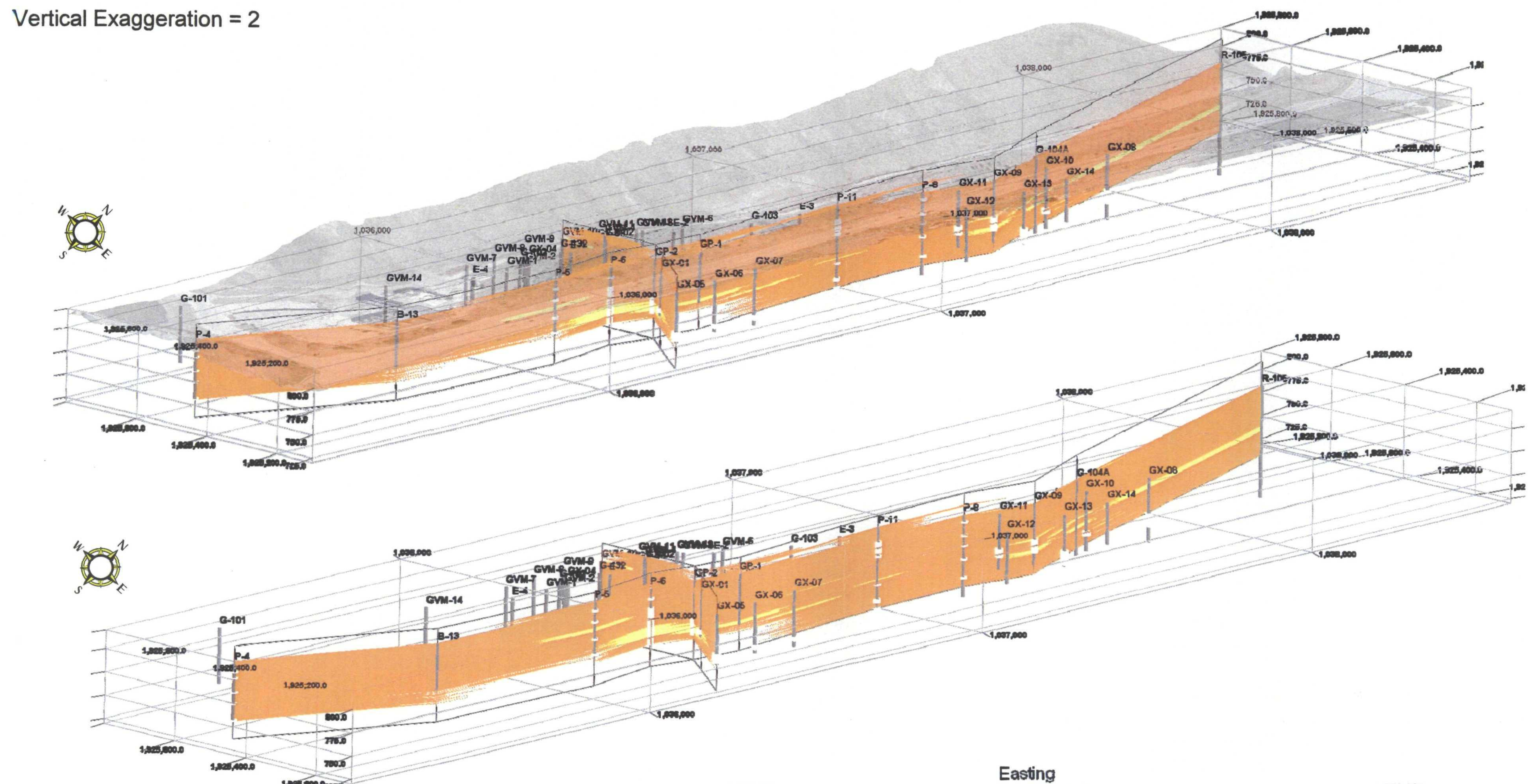
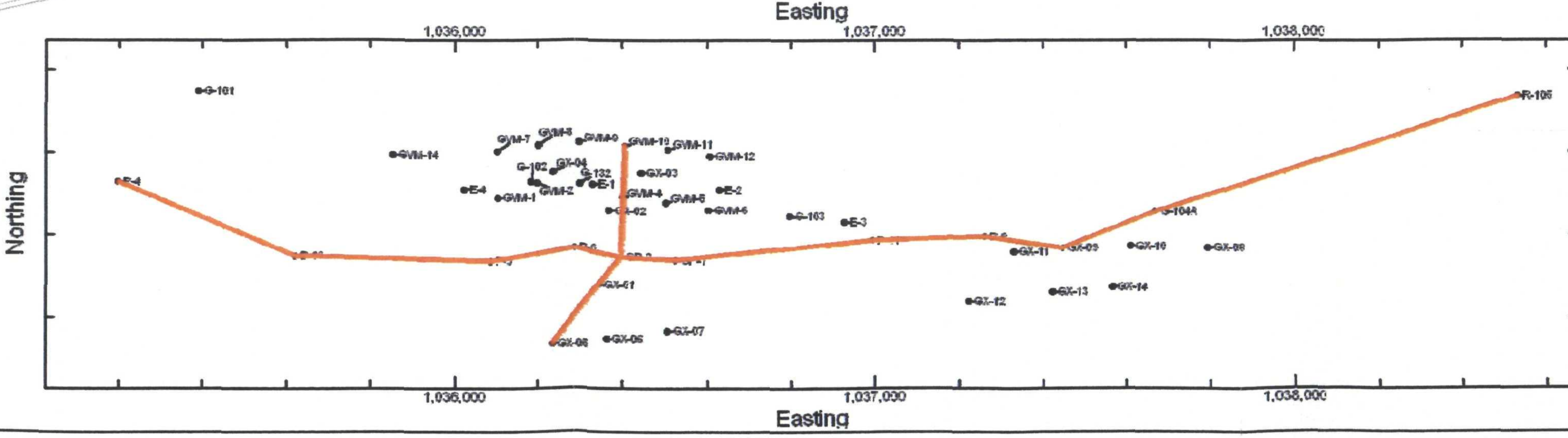
Figure
19

Vertical Exaggeration = 2



Easting



Legend

- Undifferentiated Wadsworth Diamicton
- W1/W2 Unit

Notes: This information is for reference only. Geologic correlations are based on subsurface data obtained at soil boring and CPT probe locations. Actual subsurface conditions at any particular locations may vary

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Geologic Fence Diagram South Side
Landfill Gas Migration Nature and Extent Evaluation
Mallard Lake Landfill
Hanover Park, Illinois

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Figure
20

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TOP OF W1/W2 UNIT MAP
LANDFILL MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

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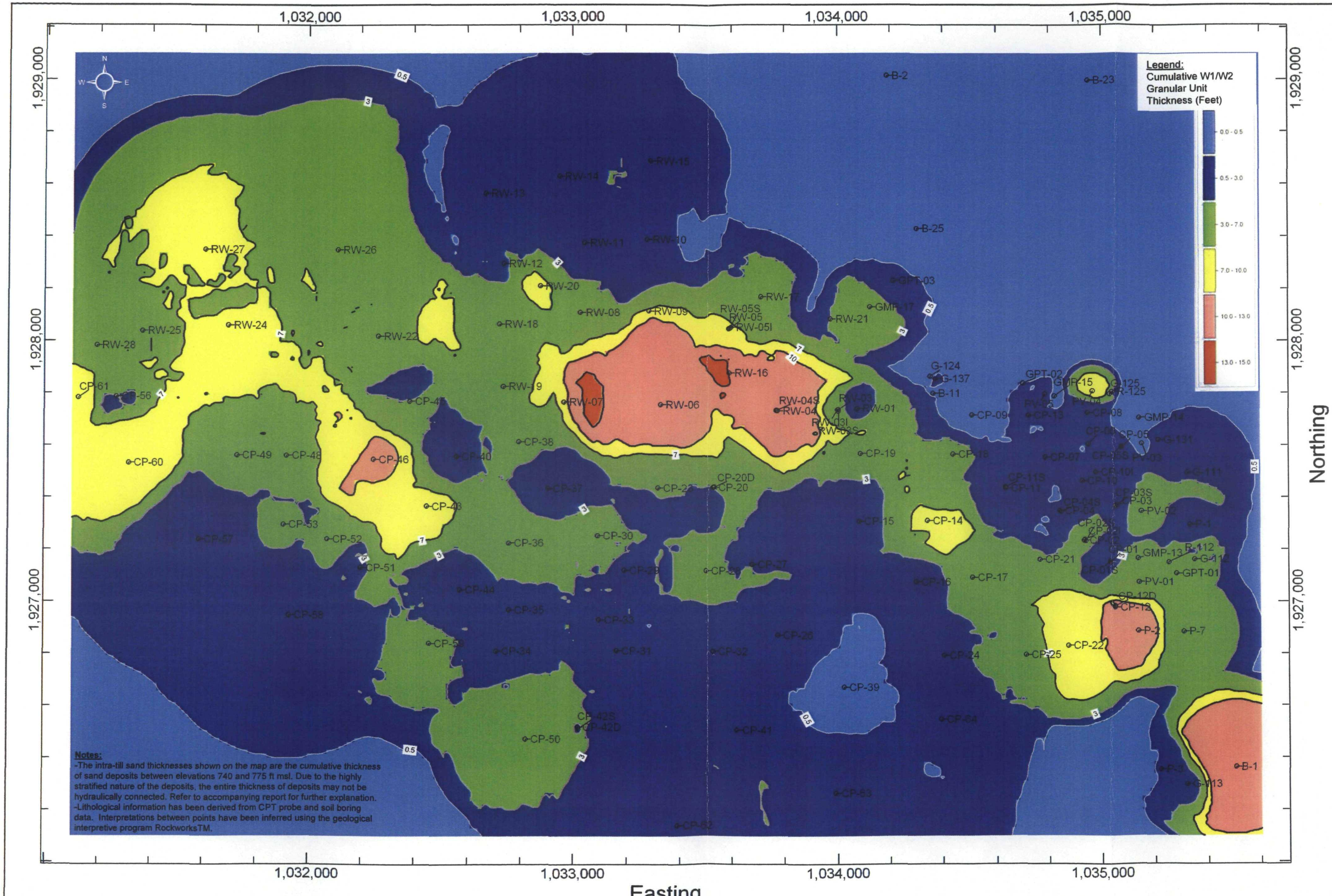
FIG. 21



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Cumulative W1/W2 Granular Unit Thickness Map
Landfill Gas Migration Nature and Extent Evaluation
Mallard Lake Landfill
Hanover Park, Illinois

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Figure
22

NOTES:

1. WATER LEVELS AND GAS PRESSURES WERE MONITORED FEBRUARY 14th THRU 16th, 2008.
2. GROUNDWATER POTENTIOMETRIC SURFACE CONTOURS REPRESENT TOTAL PRESSURE BASED ON SUM OF GROUNDWATER HEAD AND GAS PRESSURES. PRESSURE MEASUREMENTS HAVE ALSO BEEN CORRECTED FOR BAROMETRIC PRESSURE VARIATIONS DURING THE MONITORING PERIOD.
3. THE EQUIPOTENTIAL CONTOURS REFLECT TOTAL PRESSURE MEASUREMENTS WITHIN THE WADSWORTH TILL W1/W2 INTERGLACIAL DEPOSITS. THE W1/W2 UNIT IS DISCONTINUOUS AND EXHIBITS FACIES CHANGES WHICH MIGHT EFFECT THE CONTINUITY OF FLOW BETWEEN PROBE LOCATIONS.
4. VERTICAL GRADIENTS RANGING BETWEEN 0.5 FT./FT. TO 1.0 FT./FT. HAVE BEEN OBSERVED WITHIN THE WADSWORTH TILL UNIT. THEREFORE, VERTICAL DIFFERENCES IN SCREEN INTERVAL ELEVATIONS DUE TO SAND SEAM ELEVATION CHANGES MAY APPRECIABLY AFFECT THE POTENTIOMETRIC SURFACE CONTOURS.
5. THE POTENTIOMETRIC SURFACE CONTOURS ARE CONSTRUCTED TO ASSIST IN SELECTING LOCATIONS FOR GROUNDWATER QUALITY MONITORING. INTERPRETATIONS MAY BE REFINED AS ADDITIONAL DATA BECOMES AVAILABLE (I.E. PROBES WHICH COULD NOT BE LOCATED, BAROMETRIC PRESSURE CORRECTIONS, ETC.).
6. WATER LEVEL ELEVATION AT CP-55 REFLECTS DATA COLLECTED ON 3-13-2008. WATER LEVEL ALLOWED TO RECHARGE AFTER GROUND WATER SAMPLING EVENT ON 3-11-2008.

LEGEND

- G52S — G52S GROUNDWATER MONITORING WELL
- B-# — EXISTING BOREHOLE LOCATIONS
- GP-X GMP-# — EXISTING LANDFILL GAS MONITORING PROGRAM PROBE (RED IF GAS HAS BEEN DETECTED)
- G# — EXISTING GROUNDWATER MONITORING WELL
- RW-# — EXISTING RIGHT-OF-WAY CPT PROBE LOCATION
- CP25 769.21 769-759 — EXISTING CONE PENETROMETER; POTENTIOMETRIC ELEVATION; SCREEN INTERVAL
- RW8 CP15 — EXISTING CPT PROBE LOCATION w/ METHANE
- GPT-2 — EXISTING CPT PROBE WITHIN LANDFILL PROPERTY (RED IF METHANE CONCENTRATIONS HAVE BEEN DETECTED AND CONFIRMED)
- CP12-D — 2" MONITORING PROBE
- CP25 — GROUNDWATER QUALITY MONITORING LOCATIONS SAMPLED MARCH 6-13, 2008
- 762 — POTENTIOMETRIC SURFACE CONTOUR

N

150 0 150 300

1" = 150'

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ESTIMATE OF POTENTIOMETRIC SURFACE
FEBRUARY 14-16, 2008
LANDFILL GAS MIGRATION NATURE & EXTENT EVALUATION
MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

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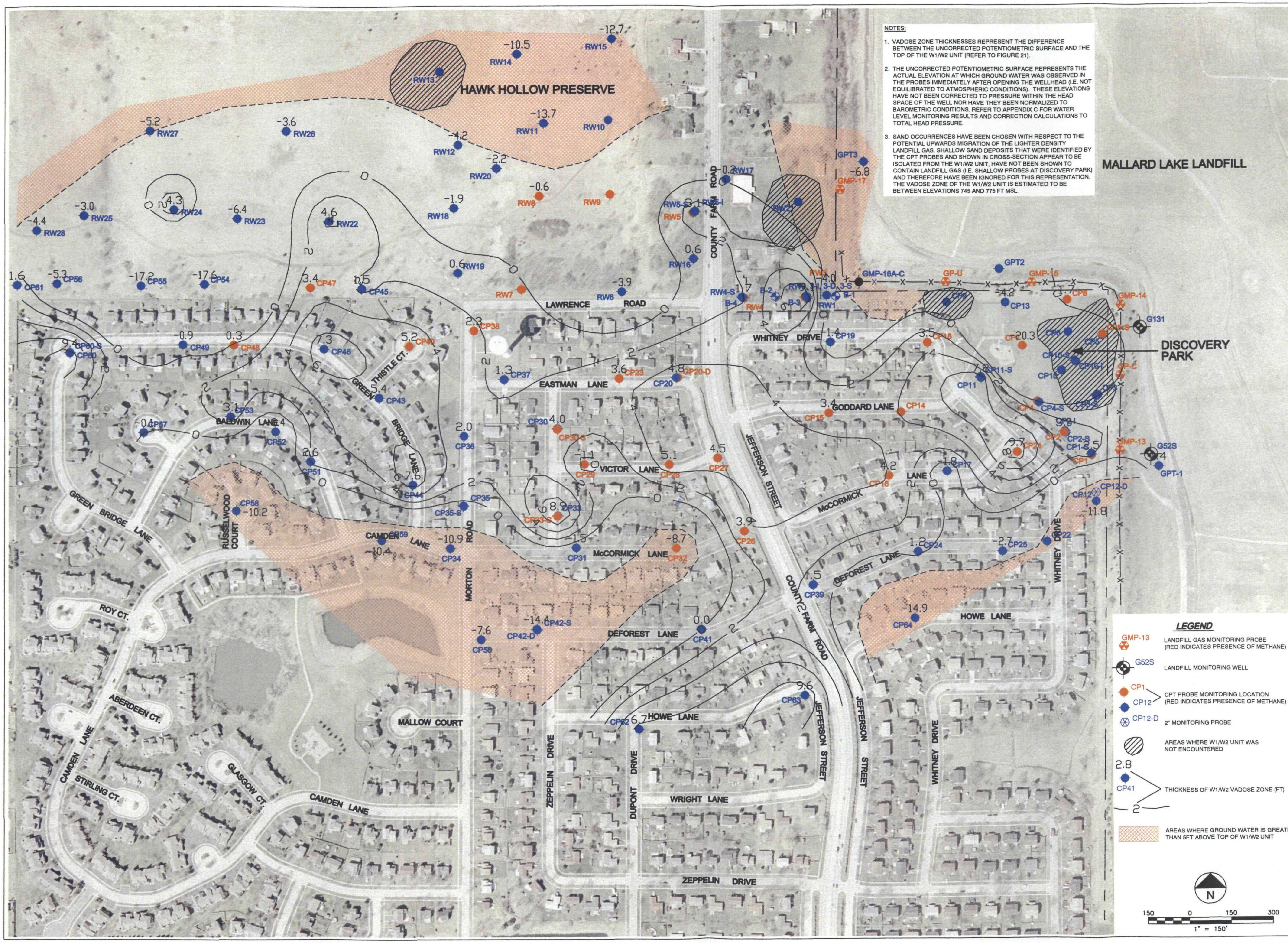
FIG. 23



NOTES:

1. VADOSE ZONE THICKNESSES REPRESENT THE DIFFERENCE BETWEEN THE UNCORRECTED POTENTIOMETRIC SURFACE AND THE TOP OF THE W1/W2 UNIT (REFER TO FIGURE 21).
2. THE UNCORRECTED POTENTIOMETRIC SURFACE REPRESENTS THE ACTUAL ELEVATION AT WHICH GROUND WATER WAS OBSERVED IN THE PROBES IMMEDIATELY AFTER OPENING THE WELLHEAD (I.E. NOT EQUILIBRATED TO ATMOSPHERIC CONDITIONS). THESE ELEVATIONS HAVE NOT BEEN CORRECTED TO PRESSURE WITHIN THE HEAD SPACE OF THE WELL NOR HAVE THEY BEEN NORMALIZED TO BAROMETRIC CONDITIONS. REFER TO APPENDIX C FOR WATER LEVEL MONITORING RESULTS AND CORRECTION CALCULATIONS TO TOTAL HEAD PRESSURE.
3. SAND OCCURRENCES HAVE BEEN CHOSEN WITH RESPECT TO THE POTENTIAL UPWARDS MIGRATION OF THE LIGHTER DENSITY LANDFILL GAS. SHALLOW SAND DEPOSITS THAT WERE IDENTIFIED BY THE CPT PROBES AND SHOWN IN CROSS-SECTION APPEAR TO BE ISOLATED FROM THE W1/W2 UNIT, HAVE NOT BEEN SHOWN TO CONTAIN LANDFILL GAS (I.E. SHALLOW PROBES AT DISCOVERY PARK) AND THEREFORE HAVE BEEN IGNORED FOR THIS REPRESENTATION. THE VADOSE ZONE OF THE W1/W2 UNIT IS ESTIMATED TO BE BETWEEN ELEVATIONS 745 AND 775 FT MSL.

LEGEND

GMP-13 — LANDFILL GAS MONITORING PROBE (RED INDICATES PRESENCE OF METHANE)

G52S — LANDFILL MONITORING WELL

CP1, CP12 — CPT PROBE MONITORING LOCATION (RED INDICATES PRESENCE OF METHANE)

CP12-D — 2" MONITORING PROBE

AREAS WHERE W1/W2 UNIT WAS NOT ENCOUNTERED

2.8 CP41 — THICKNESS OF W1/W2 VADOSE ZONE (FT)

2

AREAS WHERE GROUND WATER IS GREATER THAN 5FT ABOVE TOP OF W1/W2 UNIT

N

150 0 150 300

1" = 150'

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VADOSE ZONE THICKNESS MAP
LANDFILL MIGRATION NATURE AND EXTENT EVALUATION

MALLARD LAKE LANDFILL
HANOVER PARK, ILLINOIS

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FIG-24

Figure 25
Summa Canister Relative Chlorinated VOC Concentrations
GX1 and Transducer Blank

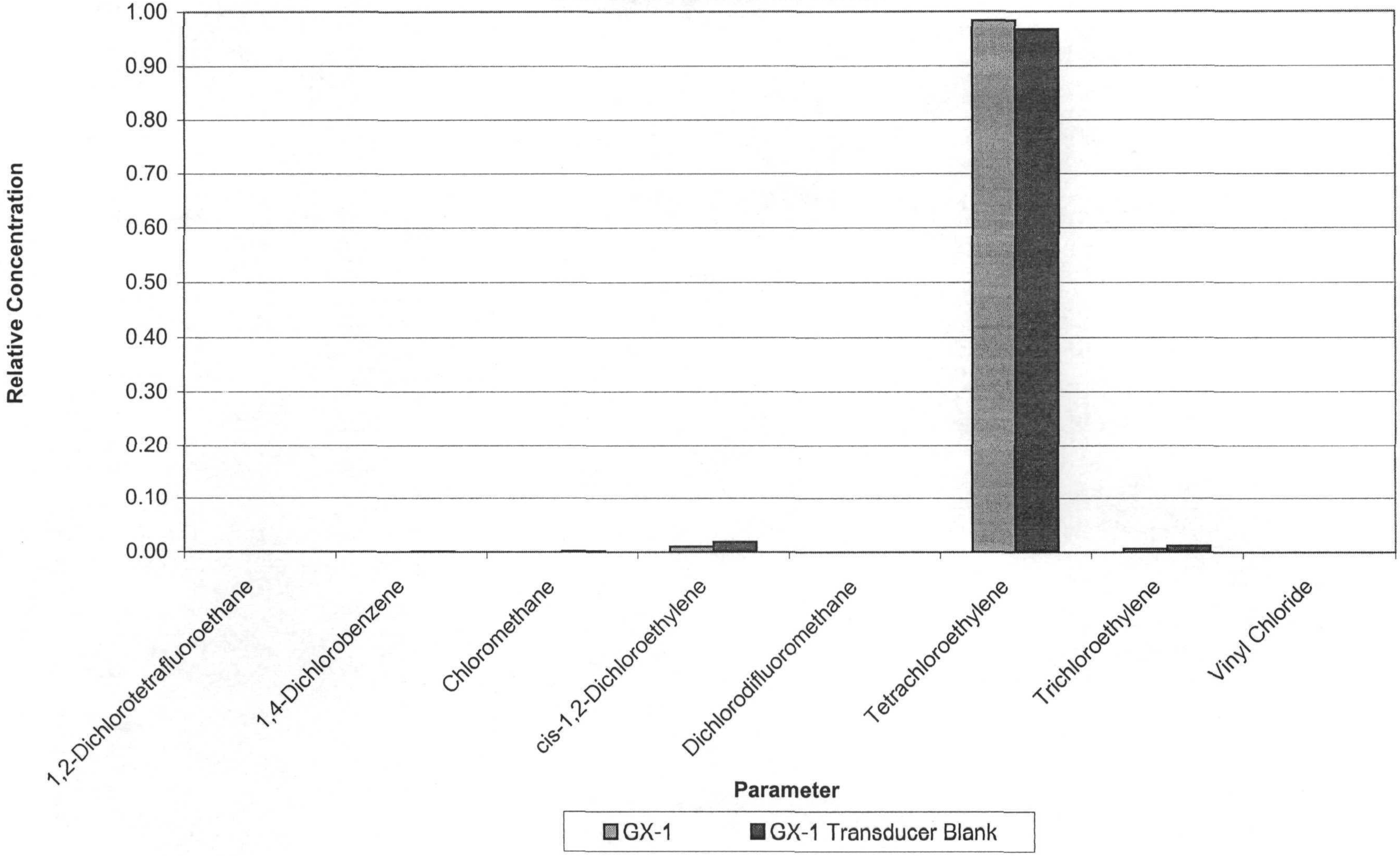

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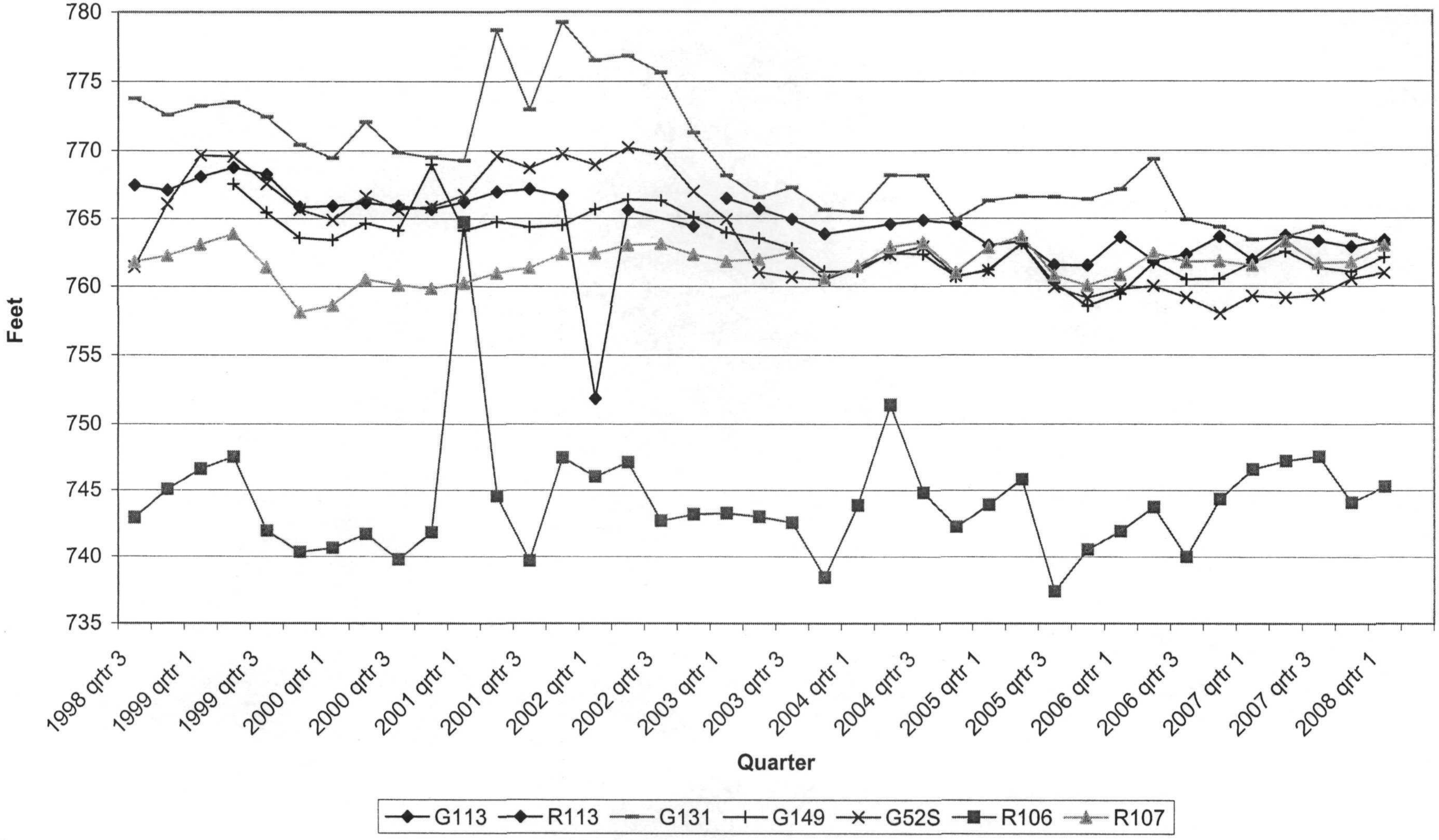
Figure 26
Mallard Lake Landfill
W1/W2 Groundwater Elevations (msl)



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Drawings

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